

A DESCRIPTION OF INVESTIGATIONS CARRIED OUT IN  
THE EQUATORIAL PROVINCE OF THE ANGLO-EGYPTIAN  
SUDAN ON A HITHERTO UNDESCRIBED DISEASE OF THE  
EYES NOW KNOWN AS "SUDAN BLINDNESS"; TOGETHER  
WITH AN ACCOUNT OF THE MANIFESTATIONS OF  
ONCHOCERCA VOLVULUS (LEUCKART. 1893), NOTES ON  
THAT PARASITE, AND ITS RELATION TO "SUDAN  
BLINDNESS".

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A FOREWORD TO THE THESIS HERE PRESENTED.

FEW HUMAN PARASITES EXCEED IN INTEREST THE NEMATODES OF THE FAMILY FILARIDAE IN THE DIVERSITY OF THEIR INSECT VECTORS, THEIR VARYING HABITAT IN THEIR HOSTS, THE RANGE OF THEIR ACTIVITIES, AND THE PROTEAN NATURE OF THEIR CLINICAL MANIFESTATIONS.

Blacklock.

INTRODUCTION.

- (1). GENERAL CONDITIONS.
- (2). EQUATORIA.
- (3). NATIVE TRIBES.
- (4). MAGIC.
- (5). POSSIBLE RESERVOIR HOSTS OF ONCHOCERCA  
VOLVULUS.
- (6). FISH POISONS AND ENDEMIC RETINO-CHOROIDITIS.
- (7). PROBABLE DISTRIBUTION IN THE SUDAN.
- (8). ILLUSTRATIONS etc.
- (9). BIBLIOGRAPHY.
- (10). NOTE ON THE SCOPE AND INTENTION OF THIS THESIS.



## INTRODUCTION.

It is possible in describing the endemic retino-choroiditis of the Sudan to separate it entirely from the hitherto known ocular manifestations of O. volvulus.

The aetiology of the conditions is so similar that a large part of this thesis must be devoted to that parasite.

The greater part of this work has been done under the most unfavourable conditions.

## GENERAL CONDITIONS & FIELD WORK.

The collection of specimens, the aspiration of aqueous from eyes, ophthalmological examinations, and examinations of cases have mainly been done in the open, or in dark, badly ventilated huts and shelters. Trained assistance has of course not been available. Constant marching in the wet has at times been very trying. Irreplaceable specimens have been lost, destroyed by insects or animals, and once the oil immersion lens of the microscope was lost when a carrier was washed off his feet in crossing a swollen stream.

## EQUATORIA.

Equatoria is still the Africa of Sir Samuel Baker, Schweinfurth, and the ill-fated Miss Tinney. Peace now reigns, and there are roads, but below the surface darkest Africa holds sway. Selous came to Rumbek to hunt the giant eland (derbiensis), and failed to find it. The great Stigand fell after a tremendous stand, riddled with spears near where this work was done.

From Wau started the intrepid Marchand in his last wild dash to forestall the victor of Omdurman at Fashoda - now called Kodok.

In Rumbek de Tombedek had all his tiny force wounded by the Dinka on his epic march to Shambe, and on by canoe to Khartoum. Here the gallant Gessi, his crews mutinous, his starving soldiers turned cannibal, contracted the dysentery from which he died; his ships stuck in the impenetrable sudd of the Bahr el Ghazal.

In Equatoria Gordon was once Governor. Three successive staffs died or were sent home sick, but that iron man lived to die years later, in far away Khartoum. A wild but fascinating country--- whilst one's health lasts. Here too perished Fergusson in 1928 speared by the Nuer.

## NATIVE /

### NATIVE TRIBES.

The tribes of Equatoria may be divided into two great groups, those that live in tse-tse country and have no cattle, and those that live in fly-free country and own great herds.

The people amongst whom this work has been done, vary greatly in culture, in pursuits, language, and mental capacity.

The Azande, as a rule, lie frankly, always with a set purpose. The Bellander have been frightened and untruthful; they are miserable people who have been hammered by all their more virile neighbours in turn.

The Jur are a race of very low mental calibre. Much of their superstitious fear has been overcome. As hunters they are from personal observation devoid of fear. They have been willing to help but their incredible amentia and wish to say the right thing has added to difficulties.

When we come to the great Nilotic tribes, however, things are very different. "To lie is contemptible; much better refuse to speak." "As proud as Lucifer and as idle as they're made", is a just verdict on these people. They are of a much higher intellectual grade than the others. If their confidence is won (and the writer has gained a fair degree of proficiency in their difficult language) it would be hard in a civilised country, to obtain more accurate clinical histories than those given by the naked giants of the Bahr el Ghazal and the Upper Nile.

### MAGIC.

What is the cause of your illness? "What did your father die from?" "How came your cow to die?" The answer is as often as not "MAGIC".

The case histories submitted here (with two exceptions), have been reduced to the requirements of the unromantic, hurried twentieth century - No place in these pages for the dark and dreadful doings of the sacred grove.

Not here the place to expand on the secret societies of the Azande. The fire-lit forest scenes of licence.

Not /

Not now the time to portray the slow passing of the poisoned cup, the opisthotinos and screams and dreadful vomiting, the horrid accompaniments of the trial by ordeal.

Yet all these things play a part in the lives of these people. Deeply religious after their own lights, spells and magic become the causes of good fortune and disaster; incantations, and the making of magic are usual in cases of severe illness, childbirth and death.

We have then modern medicine striving to extract information from early stone-age minds. The result is unhappy, and, in the prosaic recital of these records is lost the romance and folklore, -- the salt has lost its savour.

Time will not allow us to meander through Frazer's "Golden Bough", browse on the rich foliage thereof, and compare the beliefs of our forefathers with those of the Bahr el Ghazal, -- and yet how similar they are!

#### POSSIBLE RESERVOIR HOSTS OF ONCHOCERCA VOLVULUS.

In 1934, Dr. A. Cruickshank, whilst shooting with the writer on the Lau or Yei River, shot a white-eared cob (Cobus leucotis) beneath the skin of which were found nodules containing adult worms and microfilariae resembling O.volvulus in man.

The local Dinka when questioned, said that similar tumours were found in tiang (Damasellus tiang), buffalo (Cinerus kaffer egaenotalis), and in domestic cattle. On request a very aged cow was produced, paid for, and duly shot in the brain and medulla to spare it the ritual of death by the spear. The nodules beneath its skin contained worms and embryos which in vivo and when stained appeared identical with the human parasite. It is greatly to be regretted that a stray dog got into our rest house and ate our specimens before we could bottle them.

Permission was given by the game warden to shoot in excess certain animals, a limited number of which are allowed only on a Sudan Government game licence. Unfortunately pressure of ordinary medical and surgical work prevented this line of investigation proceeding any further. However Cruickshank later found a nodule in a bush buck (Tragalaphus scriptus bor) and the writer one in a tiang.

The /

The presence of a parasite so closely akin to the human one made a reservoir host not only a possibility but a likelihood especially as the human manifestations had only recently appeared in both localities.

Now baboons are frequenters of rocky streams, they are crop thieves and come close to dwellings and are specially common where O.volvulus is found. A number were shot, but no tumours were found. It was not a pleasant piece of work, for a baboon is a large, brave, and if wounded, very dangerous beast. If wounded, too, its cries of pain are harrowing in the extreme to the shooter's conscience.

#### FISH POISONS AND ENDEMIC BLINDNESS.

When the writer first began to investigate the disease now known as Sudan blindness, he was struck by two things - Firstly that the disease was found along rocky streams that looked likely to breed Simuliidae (none were seen at first on account of the season), and secondly, that a number of natives put down their blindness to eating certain fish, or parts of certain fish, - such as the roe of the great Nile perch (Lates nilotica) and other fish.

Then I was told by the Gok Dinker that the disease was only caused by eating fish improperly cleaned after fish poison had been used in their capture. Here at last was an explanation of the condition which looked as if it were the result of a systemic intoxication, the poison having a selective action on the retina. Then came the news that the fish so poisoned became blind, their eyes suffused with blood and protruding from their heads. This was certainly good news; all that was necessary would be to prohibit the use of fish poisons and this terrible scourge would be banished for ever. The commoner poisons were collected, and fed to rabbits and monkeys in the Wellcome Research Laboratories at Khartoum. <sup>2</sup> Week after week their fundi were examined with the ophthalmoscope. Some died of acute gastritis, but none developed Sudan Blindness. By this time simuliidae had been found; about this time also my friend Hennessey of The Uganda Medical Service, was working on a hitherto undescribed eye disease he called "bulge eye". (Owen & Hennessey 1932). In sections of the thickened conjunctiva of these cases he found the remains of nematode worms which he thought might be those of F.perstans. I had already found this parasite to be present in a very large percentage /

percentage of the Rumbek Jur - the people I happened to be working amongst at the time, but was unable to associate "bulge eye" with Sudan Blindness.

On leave in 1932 I spent a great deal of time looking for a description of a disease that might resemble endemic retinochoroiditis. I failed.

I then determined to search for O.volvulus. On the Nile steamer on my return from leave, I met Dr. Jean Hissette of The Belgian Congo Medical Service. He was then about to publish his extremely complete paper on onchocercal keratitis, and he suggested that although there seemed to be considerable clinical differences, the aetiology, especially the very great recent increase in the number of blind persons in certain districts, was very similar. Shortly after reaching my station, I paid a visit to the Jur country and there I found O.volvulus. This was the first record of the worm from the Sudan. The first tumour masses I bought for the equivalent of three shillings, and removed them with a local anaesthetic whilst the old woman clutched her heaven-sent wealth in her thin and dirty hand.

Here was something to work on at last.

The fish poison theory was discarded, for I now realised that where fish poisons were used, it was not possible to use the usual methods of taking fish with net and spear owing to the rocky nature of the pools. It was of course in these same rocky stretches that bred the vector of O.volvulus, and there too was "the country of the blind". But still, as yet, strong as the circumstantial evidence is, it cannot be said that Sudan blindness is definitely due to O.volvulus.

#### PROBABLE DISTRIBUTION IN THE SUDAN.

A glance at the map will show that the bulk of this work has been done in the rectangle formed by the Bahr el Gebel, the Bahr el Ghazal and the French Equatorial Africa and Belgian Congo boundaries and a line running East and West through Juba joining the Bahr el Gebel to the Belgian Congo boundary.

From recent reports from the Southern Fung, the presence of hydrocele and a recent and alarming increase in the numbers of blind seeking exemption from taxation, suggest that it might exist there also. The streams seen in the Southern Fung in 1930, looked extremely likely breeding places for simuliidae.

Fortunately /



Fortunately the disease as far as is known, does not appear in Dongola Province where the simuliidae in the winter have to be seen to be believed.

In Abyssinia, at Gambeilla, O.volvulus is known to exist, and it is thought, from information received, that Sudan Blindness is found there also.

#### ILLUSTRATIONS ETC.

Many of these are quite unique. The photographs (except the microphotos) were taken personally, and many are now in the museum of The Wellcome Institute of Scientific Research. I am indebted to Colonel Harvey of The R.C.P. Laboratories for the sections and to Dr. Wenyon of the Wellcome Institute for the microphotos of those sections. I should also like to thank my friend and trusted medical officer Dr. Ibrahim Malhamme, who at times took on his broad shoulders the whole of the very heavy medical and surgical work of my hospital to enable me to get out on trek to do this as yet very incomplete work. Good luck to him in his all too early retirement to his native Lebanon.

My acknowledgment to Dr. Hissette will be found elsewhere. To Dr. A.R. MacKellvie of my service I should like to tender my most sincere thanks for his expert help and advice in the examination of many of these cases, and for his two visits to my district.

#### BIBLIOGRAPHY.

The bibliography of this paper though extensive, is incomplete. So many references were found to be but reiterations of the observations of others, that they have been omitted.

Hissette, Sandground, Luna, Toroella, Blacklock, Silva, Ouzilleau and others have been freely quoted.

Luna describes what he calls "onchocercal amblyopia," and Hissette attributes all the cases of optic atrophy he saw during his investigations to atoxyl injected for sleeping sickness prophylaxis or therapy. The retinal and gross choroidal changes he describes beneath the microscope differ entirely from those found in Sudan Blindness.

The /

The syndrome now known as Sudan Blindness together with a description of the bulk of this work has already been the subject of a thesis at another university. The first description of the endemic blindness of the Southern Sudan was given in a report to the Director Sudan Medical Service by the writer in 1932.

NOTE ON THE SCOPE AND INTENTION OF THIS THESIS.

It would be as well to state here that this thesis makes no pretence to be a complete account of the filarial worm that occupies so much of the space in these pages. The work is meant firstly as a clinical study of the retino-choroiditis of the Southern Sudan, and the clinical manifestations of Onchocerca volvulus. The candidate therefore considers that a detailed account of the life history of the simuliidae, the development of larvae in the insect, and the minute morphology of the members of the genus Onchocerca do not come within its scope. Since much of this work has been an attempt to verify the observations of others, or is in the nature of an original contribution, only the aspects of the subjects that have been investigated personally are given in any great detail.

TRIBES, HABITS OF SAME, TOPOGRAPHY, FOLKLORE, etc.

(1). THE RUMBEK JUR

Beliefs of, as to cause of blindness.

Crops, pursuits and habits of

The Jur and scabies.

Diseases, narcotics, mentality of.

(2). THE RAIK DINKA.

Brief account of visit to.

(3). TOPOGRAPHICAL FEATURES OF TAMBURA DISTRICT.

The Bellander tribe.

The Zande tribe.

The magic, habits, and witchcraft of.

"Vouverie Zaie" or the blindness of the frog.

Zande and Bellander beliefs as to the causes of  
blindness.

(4). THE GOK DINKA.

Beliefs of.

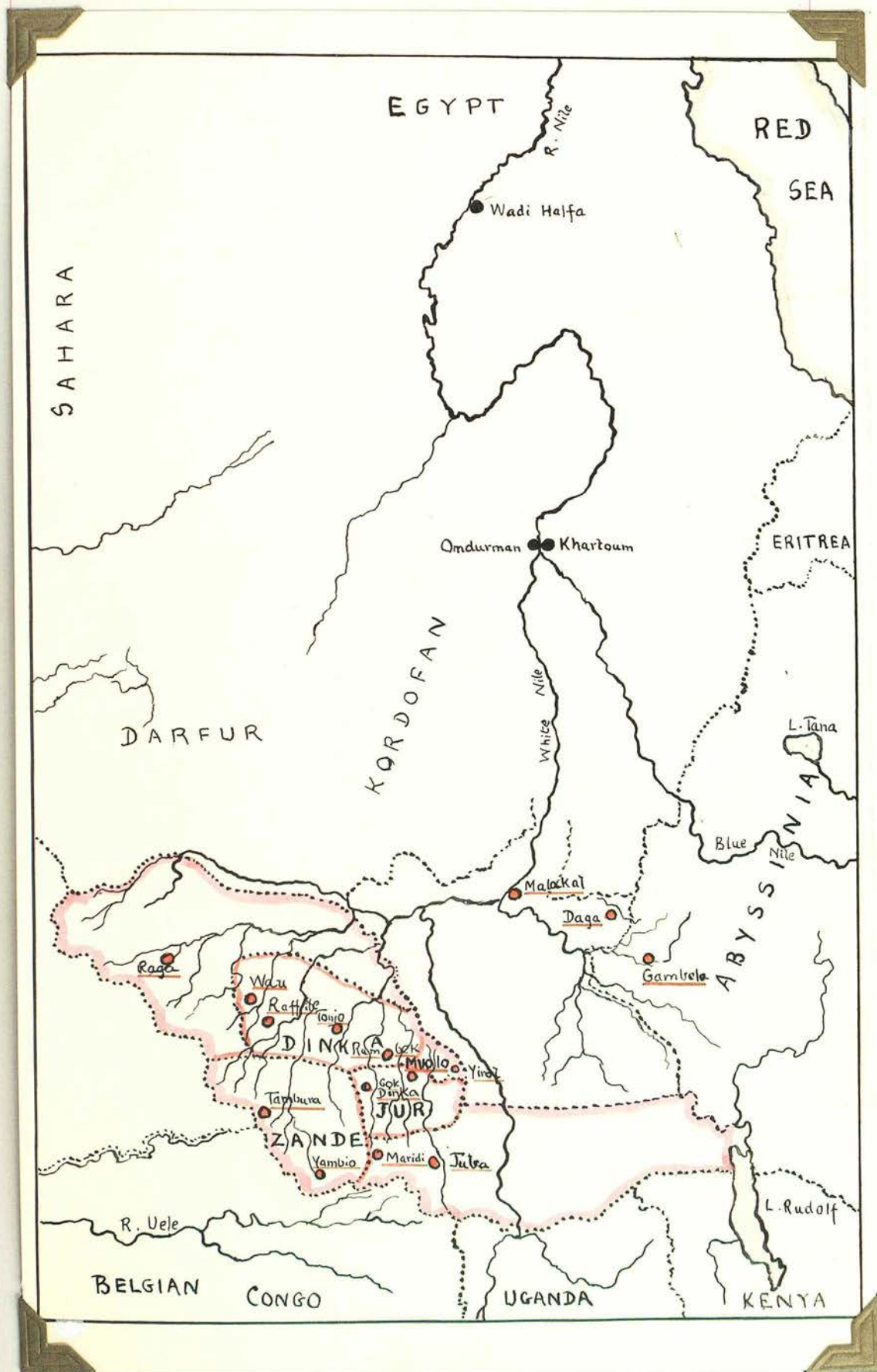
(5). SUDAN BLINDNESS.

History of.

(6). HEREDITY.

(7). CONSANGUINITY.





SUDAN BLINDNESS, NATIVE BELIEFS, HISTORY, TOPOGRAPHY.

In order that all available information about the endemic retinochoroiditis of The Southern Sudan should be examined with a view to discovering its cause, the natives have been freely questioned as to their own opinions.

Lest it be imagined that this procedure might be a waste of time in an investigation of this sort it is well to remember that it was the natives of West Africa who told scientific workers that the Chrysops was the vector of F. loa loa. Again Hissette (1932) records that in The Congo the natives believed that Simulium was the vector of O. volvulus.

To demonstrate the value of questioning these shy, and primitive peoples when their reserve has been overcome after a day's shooting by a liberal gift of game meat, some tobacco, a bowl of native beer or some other small luxury the following little incident is mentioned.

After a long and gruelling day with carriers a buffalo had been shot close to the rest house where it was intended to sleep. The local inhabitants hearing a shot soon assembled, cut up the meat, carried it into camp and during the evening there was a dance. Sitting or rather squatting by the fire was a very old man; on being asked what caused the tumours which bulged in several places on his ribs he replied that they were the result of being badly bitten by eye bees (the name for these insects and Simulium being the same in that country). He went on to say that the tumours contained very small (thin) guinea worms. On being asked how he knew, he said that occasionally the tumours were removed for cosmetic reasons, and if they were opened guinea worms would be seen. He had in fact, to his own satisfaction, named the vector of O. volvulus.

In contrast to the above the following interview is recounted. Again it was evening and we had been working all day giving injections and had ended by getting a beast for the camp. The two policemen who were acting as escort and general factotums came to report and to get their instructions for the morrow. By their rigid attitude it was obvious they had been drinking. They were given their orders and dismissed for the night. They were then called back and asked what /

what their views were about the disease which was blinding so many of their tribesmen. They declared with conviction that the blindness was the direct result of the anger of the djinns of forest, toich and stream, for the Government's steady refusal to recognise their powers, and for the Government's punishment of their agents --- dealers in the more blatant types of magic. Both these men believed what they said in spite of service with British officers and administrators for the previous ten years.

### THE RUMBEK JUR.

It was amongst these people that endemic retino-choroiditis was first seen and recognised as a definite syndrome, which for lack of a better name was called Jur Blindness.

The Jur (meaning foreigners in Dinka) are hunters and fishermen, a forest tribe living for the most part in G.morsitans country and having as a result no cattle, and goats only in a few places. Their country is watered by the rivers Rholl or Naam (in the East) and the Gell. The banks of these streams are mainly sheer and their waters sluggish as they flow through the great open grasslands which flank them. These grasslands are known as "toiches" and will be referred to as such as there is no English equivalent to this Dinker name for a special type of seasonal marshland. In the forest however these rivers have a totally different appearance. They are rocky, there are shallow runs where the water bubbles and babbles over beds of golden gravel, and slips round great boulders of rounded granite, or spurts in miniature cascades between the rocks. In flood these beautiful forest streams are shouting torrents, the tumult of their waters being audible a long way off. The toiches now become morasses covered by mile on waving mile of ten foot grass, impassable to all but the migrant herds of elephant. In places in the Jur country isolated granite outcrops of tremendous rocks occur. These sometimes resemble colossal monoliths towering over the surrounding forest. These are the castles of the baboons, sanctuary of their young from the ever present leopard; here too are countless conies (Hyrax) which look like overgrown, grey guinea pigs.

JUR /



JUR BELIEFS AS TO CAUSE OF SUDAN BLINDNESS.

1. The blood of a buffalo spurting into the eyes during the chase, or whilst cutting up the meat is apt to cause blindness.
2. Eating of a fish called "abu noke" (arabic) or loke or lake (Dinka) and also the Nile tiger fish (arabic cas). It is said by the Jur, that the abu noke carries in its operculum, a musk-containing gland, like that of the crocodile. A number of these fish after capture failed to exhibit the slightest whiff of musk in their gill covers when their heads were dissected.
3. Eating by accident or intention the totemic emblem of clan or family.
4. Cannibalism. Now about 1910 the Lado Enclave was being handed over to Anglo-Egyptian administration by agreement with the Belgian Congo. During the hiatus between the departure of the Belgians and the advent of the British, a raid on a very large scale took place. The raiders belonged to the powerful Zande tribe. The Azande were famous as much for their fighting qualities as their cannibalism. They fell upon the unsuspecting Jur and made great slaughter. Having captured all the available women (the Jur women are incredibly ugly) and children, they cleared the grain stores, and settled down to a banquet of the bodies of the vanquished; this lasted till they could eat no more --- knowing the Azandes' capacity for meat this must have been a prolonged meal. When they eventually left with their spoils, the hungry Jur crept back to their trampled clearings, their looted grain stores, and still smoking houses. Amongst the ruins they found pots of cooked and tasty food. The survivors at once fell upon the stews and only found out too late that they had but completed the Zandes' horrid work in devouring their friends and relatives. There is a strong feeling in the tribe that this act of impiety has resulted as it were in a judgment from heaven; the increasing blindness of the tribe being their punishment.

Another version has it that after the raid a party of Jurs ambushed the returning Azande raiders in the river Naam, causing great slaughter. This is not so.  
The /

The Azande after a raid on an undefended Dinka cattle camp, following on their raid on the Jur, were crossing the Naam which was in flood and swimming the captured cattle across. Unfortunately they had been tracked by the angry Dinka under chief Banjok Attar. In the middle of the swirling current the sound of singing was heard, the struggling Azande beheld behind them a line of naked spearmen dancing on the bank, spears quivered above their heads as they sang to, and called their cattle home. That was the end, the cattle sung to by name, took charge, dragged their captors out on to the bank where they were speared to a man --- the Zande is no swimmer. The waters of the Naam became tainted by Zande blood and if it enters the eyes will cause blindness.

The incident of the cattle recounted above is true in detail, but, what is more important is that chiefs of repute such as Banjok Attar agree, that the swarms of simuliidae which appeared at the time of this raid exceeded anything seen before or since. It is agreed also that this insect is far commoner now than before the raid. It seems then likely that the native belief that the increase in the numbers of the blind actually does date from about 1910. It is now known that simuliidae do vary their habitat very much; this will be discussed later.

#### THE JUR TRIBE, CROPS, PURSUITS, HABITS.

The Jur are a docile people deeply steeped in magic. They are clever and fearless hunters. Their past is a matter of conjecture. They have certain lingual affinity to the Shilluk of the Upper Nile, and the Acholi of Ugander and the extreme south of the Sudan. Slave raids by the Arab merchants of Gessi's time drove them away into the forest. Raids by the Azande, and the swift and terrible raids by the Dinka on Jur and Arab alike greatly reduced the numbers of the tribe and very nearly broke its morale.

The women insert discs of ebony into their upper and lower lips. As the years advance these discs are gradually increased in size until their mouths resemble those of the duck-billed platypus. Never conspicuous for their good looks the women now are truly hideous, the subject for ribald commentary from their very comely neighbours the Dinka. Like the female bushmen the women develop masses of fat on their hips and buttocks. The following conversation was once overheard between  
a /

a hospital dresser and a policeman. Dresser. "So you  
"are married to a Jur are you?" Policeman. "Yes! Why  
"not?" Dresser. "My God! Fancy being married to a  
"woman with a face like a crocodile."

### CROPS AND FOOD.

The Jur are experts in poisons, and have gained a reputation as magicians, and murders of some subtlety have at various times been attributed to Jur poisons administered by a kajour (witch doctor). In a tribe which specialises in archery in hunting, it is remarkable that their arrow poisons are not more powerful. To the writer's knowledge, a water buck (defassa) hit in the loin by an arrow heavily coated with the dried juice of Euphorbia candelabra, was followed for seven hours before the poison brought it to the ground. The Jur standard of archery would make the marksmen bowmen of Agincourt and Cressy turn in their graves --- it is as a rule astonishingly inaccurate.

The Jur are well supplied with food. Fish plentiful and easily taken; game is plentiful and taken by snare, pitfall, and with the spear. To see the young men face an angry buffalo armed only with soft iron spears, is to witness an exhibition of cool and collected courage that will never be forgotten. Their forest clearings are very fertile and yield good crops of various millets and ellusine. Beans are grown and large quantities of ground nuts. Tubers such as moddo, buffra (manioc or arrow root) and sweet potatoes are plentiful. The tubers mentioned and ground nuts are of course immune to the depredations of locusts --- an important point when investigating night blindness which might be due to famine. Honey is a very important item in their diet and the main source of revenue to the tribe.

### THE JUR AND SCABIES.

Now the stranger to the Jur country around that beautiful but sinister place Mvolo is struck first by the hideous old hags that run out into the road and greet him with ear splitting high-pitched trills of welcome. Secondly he will notice that nearly all these same old women will begin to scratch in unison when the car stops. Some will be frankly scraping themselves like Job with a pot sherd; another will be seen passing the knife that is the sign that she is married over her/

her body. If a doctor is known to be present a crowd will soon assemble demanding sulphur ointment. So prevalent is scabies that it is said that in the past the Jur cultivated itch so that the irritation at nights should keep them wakeful, and so enable them to slip away at dawn before the arrival of the dreaded Dinka.

The dermal manifestations of O. volvulus are dealt with elsewhere in this thesis, but it may be mentioned here that although scabies is very common in this country a large proportion of the people treated in the past for that disease have not had scabies at all, but have been suffering from pseudo-ichthyosis, filarial crawl-crawl, and the other skin eruptions associated with O. volvulus. The thickened, wrinkled, skin with little pustules and resembling crawl-crawl, is called by the Dinka "Jurs' skin", whilst the Jur and many Dinka call the condition "elephant scabies" (joyn akon. Agar Dinka). In the writer's experience the M.F. of O. volvulus have always been found in the superficial layers of the dermis in this condition; it is known that M.F. are frequently absent in the pustules of true crawl-crawl.

#### DISEASES, NARCOTICS, MENTALITY, COSMETICS.

Besides the conditions associated with O. volvulus and scabies and the presence of F. perstans in from 70 to 90 per cent of adults there is nothing very special to note in this tribe.

Antimony is not used as a cosmetic on the lips as it is in so many parts of the Sudan and is not therefore associated with retino-choroiditis.

Tobacco is smoked or chewed by all and sundry from the very young to the aged. Hashish (Cannabis indica) is grown in the forest, widely smoked, and sold to the Dinka with the most unhappy results, as a Nilotic with a head bemused with hashish becomes highly excited and often homicidal. The Jur are of a very low mental calibre. Fortunately they responded well to medical work and their confidence (carefully nursed by the writer) gradually improved so that most of the preliminary work of this thesis was done in their country.



THE RAIK DINKA. A BRIEF ACCOUNT OF A SHORT VISIT TO  
THEIR COUNTRY. BLINDNESS AND ITS BELIEVED CAUSES.

By the kindness of Capt. G.M. Richards, M.C. and Capt. J.S. Poole, D.S.O., M.C., O.B.E., District Commissioners of Tonj District, a meeting was arranged between Dr. A.R. MacKelvie and the writer and a section of The Raik Dinka living on a stretch of The Tonj called Wan Alell, (Father of Rocks). Chiefs and sub-chiefs brought any blind persons in their districts to see us.

The Tonj 200 miles further south is known as the Ibba in the Zande country. The stream in its upper reaches is rapid, its banks heavily clothed in forest, and its bed rocky and gravelly in parts.

In the Dinka country its banks are sheer and of cotton soil; the bed of the river is sandy in some parts and muddy in others. At Wan Alell however the river is much wider than elsewhere, and is held up in the dry weather by a natural barrage of iron conglomerate which splits the stream into several channels in the rock, the water finding the lower levels in a series of small water falls. At the time of our visit no simuliidae were seen but a few miles further up stream swarms of these midges were reported a month earlier in a place where there are no rocks. About 40 blind persons were seen; rather over half were suffering from typical Sudan Blindness, and the remainder from onchocercal keratitis. Time did not allow of case histories being taken, but in quite a number the black refractile ring (described elsewhere) was seen in the lens of some cases suffering from typical Sudan Blindness. These rings were best seen using a plus D. 16 or plus D. 20 in the ophthalmoscope. Nearly all the histories were of short duration, very few exceeding three years. Several cases were seen in which no manifestations of O.volvulus were found.

The usual questions were asked as to native beliefs as to the cause of the disease. The chief replied in a rather doubtful manner, that God (Nialich, the one above) caused the blindness. On being further questioned as to whether he had heard that excessive eating of fish had anything to do with it or if it could be attributed to eating fish taken with poison, he replied that fish had nothing to do with the illness that was blinding his people. "Listen Black and White Bull. This sickness is caused by the little flies you Turks call 'nimitte'", said the chief assuming a confiding squatting /



ting attitude by the writer's chair on the river bank and calling him by his Dinka name (Miryial Dit). "When the flies are very numerous they drive our cattle mad. If we are fishing and are badly bitten our faces swell, our bodies itch and we go blind". The chief was then asked what doctor told him that. A fine figure of a man leaning on a bunch of large and highly polished spears replied with the inimitable hauteur of the Nilotic; "No doctor told us, but that is what we believe, and what is more the midges are the cause of the trouble".

It was the general opinion of those at the meeting that the disease had always been present, but that during the last three years the number of the blind had increased very greatly, and that the simuliidae had also become much more numerous at the same time. From the number of young people afflicted and the short histories given this information was probably correct.

Nobody having seen the pathetic spectacle of those 40 magnificent specimens of Dinka manhood peering blindly upwards into the afternoon sunshine from beneath a huge wild fig tree would forget it; or the equally sad sight of a line of shining, naked men most well over six feet in height, their blue and green beads and heavy ivory armlets flashing in the sun, groping their way along the road to see us, led by a tiny child or an aged mother by means of a spear shaft.

The change of taking histories from these people and being able to get a no that was a "no" and a "yes" that was a "yes" and a time and duration that could be relied on was most refreshing after working with the honest but stupid Rumbek Jur, and the equally stupid but suspicious and untruthful Azande and Bellander.

The Raik Dinka use no fish poisons, but the Bongo a few miles up stream do so; they are very badly affected with O.volvulus and the two kinds of blindness. They are a tribe closely resembling the Rumbek Jur in appearance and pursuits, but owing to lack of time have not been closely studied.

TOPOGRAPHICAL /

TOPOGRAPHICAL FEATURES OF TEMBURA DISTRICT. THE ZANDE  
TRIBE. HABITS AND WITCH DOCTORS.

Tembura District and the Zande country generally is mainly heavy forest. Many springs infested with G. palpalis are found. Many of these springs are surrounded by gallery forest of enormous trees which towering to a hundred feet or more without branching produce a twilight effect. Their trunks might well be the pillars of some vast cathedral aisle; one instinctively talks in a whisper beneath the lofty arches of the vault whilst the sunlight filters through gaps in the heavy foliage in brilliant shafts of blinding intensity. Great creepers hang in sweeping curves between the trees and here and there, high overhead, droop cascades of scarlet blooms. So tall are the trees that the only comfortable way to watch the black and white colobus monkeys and chimpanzees is to lie on one's back on the damp and reeking ground.

Around Tembura itself small rocky hills rise sharply from the forest to the height of two or three hundred feet. From the tops of these hills the equatorial forest can be seen stretching away on all sides, the rolling sea of tree tops being broken here and there by the granite hills. Streams will be seen meandering through the forest flanked by open toiches.

THE BELLANDER OF TEMBURA DISTRICT.

These are not to be confused with that section of the tribe which was moved to the Wau - Bo road some seven years ago for sleeping-sickness control purposes. The Tembura Bellander have always lived on the Tembura reach of the river Sueh, which is heavily overhung with forest and swift and rocky in many places. These rocky parts alternate with long deep pools which hold a heavy stock of hippopotami at most times of the year.

The Tembura Bellander are hereditary slaves of The Azande and resemble them so closely that the case histories and beliefs will be given in the same section. Both the Bellander of the Bo road and those under discussion now are great fishermen but the Tembura people do not suffer from blindness to the same terrible extent as those on the Bo road. Near each other some 20 miles from Tembura there are two villages standing well above the river and separated by a deep gully which after rain is a running stream. The two communities quarrel /

quarrel bitterly each year over the fishing rights of certain pools. Now the people to the north of the gully suffer from hydrocele and elephantiasis, whilst a great many, in fact a tragically large percentage of those to the south of the gulley are blind. O.volvulus is very common on both sides and it is believed that both blindness and hydrocele are due to it. It is said that during the frequent and acrimonious quarrels that take place between the two villages a man from one side will finish an argument by shouting "anyway you're all "as blind as bats" to which the other will answer "all right big testicles".

### THE ZANDE TRIBE.

The Azande are agriculturists and hunters. The craving for animal protein and their filthy feeding habits are the result of the difficulty in taking game owing to the constant harrying of the same, and the absence of cattle owing to tse-tse. As is well known the "nymum nyum" (for so they were known to the arabs on account of their greed in consuming human or other flesh) were a warrior race, who had it not been for the intervention of the Government would have slowly pushed the far more dangerous and better fighting Dinka out of their cattle country. The Dinka, being largely nomadic, has to find grazing for his cattle and as a result he is (fortunately) seldom able to combine. The same is true of the Dinkas terrible and dreaded foe the Nuer.

The Azande were never conquered by the slavers as is so often believed by the ignorant Arab. There were three great expeditions against them by Arabs all of which ended in a wholesale massacre each time near Tembura. No further attempt was made to enslave them.

The Azande are a happy cheerful people, superficial in character, and of a strong stocky build. They are excellent carriers.

### MAGIC, WITCHCRAFT AND HABITS.

Magic probably takes a bigger place in the life of the Zande than anyone else in the country. Never a day passes but what he retires with his special chicken (his familiar spirit of the moment) into the forest and communes with it. After dawn in the Zande country the subdued /

subdued beat of drums is heard from different points in the forest, here again somebody is enquiring after the fortunes of the coming day. No hunting expedition starts without a propitiation to some woodland spirit. The flight of birds, ants crossing the path, the appearance of some small animal at a certain period of the chase, all have their own significance as to the success or failure of the party to procure meat.

Much needless suffering is caused by the grip of the witch doctors on the people. Even hospital orderlies who have seen the results of scientific medicine, frequently consult these rogues and when at last they are compelled to cease work from pain and incorrect treatment, they are often found to be in an appalling condition. It is seldom that wives or nursing orderlies or their families are brought for treatment without having been "treated" by a kajour.

The great kajours of the Nilotic tribes, powerful though they be, have nothing like the personal hold over their people that the Zande exercise. Their power is political, they are rain makers and doctors, and their treatment of burns (by some tannic acid method they keep secret) and fractures is as a rule good. Woe betide them however should their power to produce rain fail them. If a Zande rain maker fails to produce rain, and if he is unable to convince his followers that some subtle combination of magicians is out against him, he is tied to a chair and immersed in a spring until rain does fall.

In Dinka country in hospital, permission to make a sacrifice and take a hopeless case to a kajour is never refused if the journey will not entail much suffering.

These remarks may appear irrelevant, but they are important when it comes to taking histories, as everything takes on a magical significance. Nilotics if their confidence can be gained, and their pride and reserve overcome, give very good and accurate histories.

The Azande on the other hand are far more magic-ridden; they are apt to conceal facts and symptoms, and their capacity for lying is only equalled by their infinite capacity for conjugal infidelity.



"VOUVERIE ZAIE" THE BLINDNESS OF THE FROG. ZANDE AND  
BELLANDER BELIEFS AS TO CAUSE OF SUDAN BLINDNESS.

1. Magic or all the combinations of same with witchcraft and forest lore.
2. Eating the head or hard roe of the Nile Perch (*Lates nilotica*.) It is generally thought that the perch is blind. Those who have been fortunate enough to be able to fish for these huge sporting fish will have been struck by their blazing yellow eyes. In the Sueh river and in the Bahr el Ghazal their eyes are often a brilliant red. The cornea appears semi-opaque and the vivid retinal reflex in sunlight gives the impression that one is looking at a coloured but frosted electric light bulb. A few attribute the disease to eating the Abu Noke as do many of the Rumbek Jur.
3. The eating of poisoned fish that have been improperly cleaned. The same belief is held by the Gok Dinka.
4. Eating frogs and toads. The blindness is known as the blindness of the frog -- vouverie zaie (Zande). A distinction is made between the frog and the toad. There is an interesting parallel in the belief of these people and our ancestors of Shakespeare's time, that a toad carries in its head a jewel of great worth. The Azande affirm that the stone in the head of the toad is deadly poison. The writer has been told also by Azande that the toad is capable of spitting poison into a persons eyes at some considerable distance. The same belief is held today in Dorset and Devon. Owing to the highly irritant poison present in a toad's skin these backtrians are always skinned before being eaten, whilst a frog is eaten skin and all; the toad of course has the mythical and deadly stone removed from its head before cooking.

GOK DINKA BELIEFS AS TO THE CAUSE OF THE BLINDNESS.

A certain amount of work has been done amongst these people. Like all Nilotics they are cattle-owning but have more extensive and better cultivations than most Dinka. This is probably due to Jur influence as the latter have been for many years a serf tribe to the Gok but living in tse-tse country and so owning no cattle. The Gok live on the Gell river and are of exceptionally fine physique. They are about the only tribe who have steadfastly upheld the Government during all the troublesome times in the unruly Dinka countries. Their loyalty has of course enabled them to fight their hereditary foe the Agar Dinka with the maximum of Kudos and the minimum of risk.

### BELIEFS OF THE GOK.

1. Eating fish poisoned with the seed cases of a wild gardenia (Randia nilotica).
2. An act of God, either the supreme Deity of the Dinka --- The One Above --- Or of the bad God in distinction to the supreme Deity.
3. The curse of a kajour, either on account of personal spite, or some enemy having hired the services of the said kajour.

Onchocerciasis is not very common in the Gok country but it is believed that blindness is increasing. Couching for cataract was very rife, the operation being performed by a Fellani, a native of Nigeria. Far be it from the writer to disagree with so eminent an authority as Colonel Elliot, but it must be admitted here that in the writer's opinion and that of the ophthalmic surgeon in Khartoum (Dr. Mackelvie), the dislocated lens lying free leads to complete loss of vision. Why this is so is not known, but we agree that a retinal atrophy sets in, and even if the poor patient does not develop the panophthalmitis and loss of both eyes which usually follows couching and does see for a month, complete blindness invariably follows. It was found that this Fellani was operating with a dirty thorn on any kind of eye trouble and charging seven goats a time. His activities have been cut short by a timely charge of hurt brought by the writer. After serving his lengthy sentence he will be repatriated to those realms where he will doubtless continue to practise his heartless fraud on the ignorant moslem community, secure too perhaps under the approval of a paternal but misguided political officer.

### HISTORY OF ENDEMIC RETINOCHOROIDITIS.

Every opportunity has been taken of questioning all the more intelligent old men in the very big area in which this work has been done, and some of them must be of very great age. The following brief notes are the meagre gleanings of those enquiries.

There can be little doubt that the disease has been known for a very long time. It was present in the Zande country before 1880, and before Gessi conquered the Bahr el Ghazal and destroyed the slavers.

It/

It was known to the Gok Dinka and the Jur before the coming of the Arabs --- probably about 1830.

There is little doubt that the disease has increased very much in the last ten years. Enough evidence has not been collected in the Gok or in the Agar to say whether or not the disease has increased to any great extent but the writer is certain that it is increasing at an alarming rate amongst the Jur, and amongst the Bellander, and especially among that section of the tribe that was moved to the Bo road for the control of sleeping-sickness. The disease might now be called epidemic in that region, it is so prevalent.

In reading Schweinfurth's remarkable book on his travels in Equatoria, the writer followed his journey up the rive Rholl or Naam to the Jur country and Rumbek. He visited Mvolo and Toynia twice; both these places are in the Jur country and it is hardly likely that such an acute and accurate observer would have failed to notice the numbers of the blind had they been as common then as they are today at Mvolo and along the river Naam to Toynia.

More recently a note appears in the province diary at Wau, that hydrocele and night blindness <sup>are</sup> ~~is~~ very common around that town; this was in 1911.

The disease must have been missed for many years because until recently Equatoria was a military area, and a doctor's duties did not extend very far beyond the supervision of troops and fighting trypanosomiasis. Unless possessed of a private ophthalmoscope the fundus changes would not come under the observation of a military doctor. Again the damage done to childrens' eyes by measles, smallpox, and trichiasis, the result of trachoma, but more often the chronic irritation from the dusty cattle camps, caused the corneal opacities of onchocercal keratitis to be overlooked. The nodules of the parasite were possibly mistaken for the juxta-articular nodules of tertiary yaws, and has not more than one eminent authority aspirated a juxta-articular node expecting to find microfilariae?

A good deal of unnecessary misgivings was aroused at one time by natives themselves. Many had never seen a British doctor before. The wonder of new and marvellous remedies were noised abroad, and the African with his love of a good story described the doings of a new and mad Englishman, benevolently mad be it noted, who peered into the eyes of the blind with a small, bright light, "yea even into their ears with a musical instrument, seeing the sunlight on the other side. By God? Yes verily! By God".

## HEREDITY. IS ENDEMIC RETINOCHOROIDITIS A FAMILIAL DISEASE?

In 1932 whilst investigating this subject on the Bo road near Raffalie Mission in the Bellander country with Captain Burrows of the R.A.M.C., we were told that the children of a blind man would probably go blind too. It must be admitted that quite a number of cases seen at Raffalie looked very like retinitis pigmentosa, in which a hereditary tendency is often well marked. In the Rumbek Jur, members of the same family were often blind. On further enquiry of the Holy Fathers, we found that their information was very faulty on many points. It was interesting too to learn that certain drops of a very special and secret nature sent from Rome were most efficacious in the treatment of the various eye complaints encountered at Raffalie. It is to be regretted that a sample of this remedy was not forthcoming for use amongst tribes less fortunate in their situation. However boric lotion has usually been found a safe and often efficacious eye wash.

Since the above note was written it has been shown that simuliidae do become truly domestic on occasion (Bryant. 1935) and this would account for the high family incidence in certain fishing communities of onchocercal keratitis, and elephantiasis, and of Sudan Blindness if this disease is due to that parasite also.

## CONSANGUINITY.

Amongst the Dinka and Nuer, the laws governing incest are very clearly laid down. Cousins may not marry, and marriage or illicit intercourse between even members of the same clan is forbidden in the first instance, and very severely punished in the second. With the ruling class of the Zande marriage between half brother and sister is common, and in the households of very powerful chiefs the rule. In view of the importance of consanguinity in retinitis pigmentosa this question has been very carefully gone into. No evidence can be found to justify an association between intermarriage and Sudan Blindness.



ONCHOCERCA VOLVULUS. A BRIEF REVIEW OF THE LITERATURE  
DEALING WITH THAT PARASITE UP TO DATE, WITH REFERENCES  
IN CHRONOLOGICAL AND NOT ALPHABETICAL ORDER. ALSO A  
SERIES OF SHORT NOTES ON ITS CHARACTERISTICS,  
MICROFILARIAE, AND MEASUREMENTS.

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NOTES ON THE INCIDENCE OF ONCHOCERCIASIS.

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A BRIEF REVIEW OF THE HISTORY OF THE LITERATURE UP TO  
DATE DEALING WITH ONCHOCERCA VOLVULUS AND ITS  
MANIFESTATIONS.

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In 1893 Leuckart received from a German missionary on the Gold Coast some material from which he isolated some fragments of worms which he named Onchocerca volvulus. The genus having been originally described by Deising (1841).

Six years later Labadie Lagrave and Deguy (1899) described an immature female lying free in a dilated and inflamed lymph vessel. The material was from French Equatorial Africa.

Prout (1901) isolated a complete male from a tumour from Sierra Leone and described the tumour in detail.

Brumpt (1904) attributed the fibrous tumour around the parasite to an inflammatory process, and pointed out that tumours were always found where lymphatics were most numerous.

To Fulleborn (1908) we owe our first really complete accounts of this worm with very good and accurate illustrations. His subsequent publications (1924 & 1929) were the most complete until the combined work of Strong, Sandground, Bequaert, and Ocha (1934), covered the whole of the pathology, aetiology entomology, and helminthology of Onchocerca volvulus in the New World and compared their findings with their previous work and that of other African workers.

Ouzilleau (1913) found a very heavy infection with O.V amongst the natives of a part of the Congo living along a tributary of that river called the Ubangi. He was the first to associate elephantiasis, hydrocele, and lymph scrotum with this parasite, and was the first to suggest that it was the cause of any other manifestation except nodules.

Dubois (1916 & 1917) confirmed Ouzilleau's findings, and in support of that worker's theory regarding elephantiasis and hydrocele reported that Wucheria bancrofti was unknown in that area.

Robels noticed the American form of the disease in 1916. A year later Calderon (1917) found nodules on the head and neck of natives of Guatemala; these contained/

contained microfilariae resembling O.V. He also noticed that certain eye conditions and a disease called "eresipela de la costa" were always associated with those nodules.

Brumpt (1919) described certain morphological differences between the African and the American parasite which he considered to be sufficiently characteristic to warrant the naming of the worm Onchocerca caecutiens or the blinding filaria.

From Luna (1921) we have our first description of the punctate keratitis which he calls "keratitis punctosa onchercosa".

Returning to Africa we find Montpellier and Lacroix (1920) have found that the skin itch of native troops which they associate with the m.f. of O.V. to be identical with the condition called crawl-crawl described by O'Neil and which he believed to be due to microfilariae as far back as 1875.

From 1921 onwards Ouzilleau and his co-workers in the Belgian Congo in several papers described various conditions which they ascribed to Onchocerca volvulus including, elephantiasis of the genitalia, hydrocele, pseudo-ichthyosis of the skin, lichenisation of the skin, and possibly crawl-crawl and keratitis besides various nutritional disturbances.

In Nigeria in 1926 Dyce Sharp reported a heavy infection amongst natives with O.V. He points out the coincidence of the skin and genital conditions and nodules, but states that he saw no ocular manifestations. He goes on to say that the absence of eye lesions is the only distinguishing feature between the African and the American form of the parasite.

It was left to Blacklock (1926 & 1927) to incriminate finally the simuliidae as the vectors of the genus Onchocerca in man. The final success of his work lay in looking for an agent that would scarify the skin since the embryos are not found in the blood except very rarely, but in the superficial layers of the skin. Two arthropods fulfilled these postulates namely the larvae of the congo floor maggot (Ocheromyia luteola) and the simuliidae. Both were common in the country where he was working.

The Harvard African Expedition (1930) confirmed Blacklock's findings and Hoffmann (1930) described the development of what he still calls O. caecutiens in S. museri.

Since/

Since then a large number of papers have been published both on the African and American forms. The most important of the latter is the report by Silva (1932) on the work of the Onchocerca Committee of the Department of Health of Mexico. In this report is given the work of Torocella and Ochoterena and the pathological details of Luna's work on the eye diseases. Silva whilst not entirely discrediting a toxic element, maintains that the microfilariae in the substance of the cornea and the other structures of the eye are the principal agents in the production of eye symptoms.

Hissette (1932) published a long and very important paper on the manifestations of Onchocerca volvulus in the Belgian Congo. It was this paper that finally gave the death blow to the, by then, very unconvincing theory that the American disease and the African were not the same. It was a conversation with Hissette in 1931 shortly after the writer had recognised the disease called Sudan Blindness that led to him (the writer) looking for O.volvulus.

In 1934 came that monumental publication by the Harvard University Press in which a team consisting of Strong, Sandground, Bequaert, and Ocha, review the whole of the work hitherto published on the genus Onchocerca, and by careful technical researches confirmed or discounted previous investigators.

Manson-Bahr (1929) believes that the American disease was imported with slaves from West Africa and that now the African disease is known to cause as severe eye symptoms as the American there is no further need to try to distinguish between the two.

Bryant in 1935 published his findings on a hitherto undescribed disease of the choroid and retina which he called "Sudan Blindness". His first report to The Director Sudan Medical Service contained the statement that he believed the disease to be due to Onchocerca volvulus which he had found for the first time in The Anglo-Egyptian Sudan (1932). He confirms the opinions of previous African workers as to the dermal and genital lesions ascribed to O.V. and Hissette's observations on the ocular manifestations in Africa.

This thesis is a resumé of that work in a fuller form.

# ONCHOCERCA VOLVULUS, ITS MEASUREMENTS AND CHARACTERISTICS.

Onchocerca volvulus is a long, slender, worm, which is usually found encapsulated in dense fibroma-like cysts in various parts of the body usually beneath the skin overlying bony prominences such as the mastoid processes, iliac crests and the ribs.

The females are usually so tightly interwoven, and firmly embedded in the fibrous tissue of the cyst, that it is exceedingly difficult to obtain complete specimens. The males are shorter and can quite often be disentangled without very much trouble.

The following measurements are given by Strong (1934) and were obtained by Sandground after very careful study of the American and the African parasite.

## MALES.

### AMERICAN FORMS.

Length--18.8--32mm.

Three from Rumbek.

Breadth--0.13--0.21mm.

### AFRICAN FORMS.

Length--20--45 mm

28, 29.5, 31mm (1933)

Breadth--About the same.

## FEMALES.

Length--335--500 mm (Sandground) Length.--230--700 mm

115--387 mm (Hoffmann & Vargus 1931)

387 mm (J.B.

Malakal 1936)

Breadth-- 0.27--0.40 mm

Breadth. As in  
American form.

## MICROFILARIAE.

The female is viviparous, and in smears from cut nodules will be seen besides eggs containing developing embryos, and the long pale staining form of the parasite, with a definite clear cephalic space at its anterior end, very much shorter and darker staining forms. It is a noticeable feature of the m.f. that they vary greatly in length, but many short larvae will be seen in the skin that do not show the deep blue staining and the lack of a cephalic space of those from the nodule.

Now/

Now occasionally one of these very darkly staining embryos will be seen in the skin. Strong has tried to explain the difference by suggesting that the two types represent male and female microfilariae.

The writer gave the matter a good deal of thought before Strong's work was published, and came to the conclusion that the short dark forms looked very like the embryos coiled up inside the eggs before hatching in the uterus of the parent worm. He still believes that these short dark larvae are imperfectly developed or developing microfilariae. In the smears from the nodules it will be seen that the small dark larvae are the most numerous.

#### MEASUREMENTS.

As mentioned above the microfilariae differ greatly in length. The long forms vary from 285 -- 360  $\mu$  in length and are from 6 -- 8  $\mu$  broad. The short forms are from 150 -- 250  $\mu$  long by 7 -- 9  $\mu$  broad.

The microfilariae are sheathless, and the parasites with which they are likely to be confused are the microfilariae of F. perstans. The two commonly occur in the same patient, and if a drop of blood is placed beneath a cover glass the larvae of F. perstans will be seen wriggling about in the preparation, if they are present, whilst the appearance of larvae of O. volvulus is exceedingly rare in the blood. Beneath the higher powers of the microscope the "puff adder-like" sharply pointed tail of an onchocercal larva is quite conspicuous. When stained with Giemsa the tail of a perstans embryo is seen to be blunt and the column of cells continues to the tip, whereas in O. volvulus the cells cease some distance from the extremity.

#### DISTINGUISHING FEATURES OF THE ADULT WORMS.

It is not intended to attempt to give a detailed description of the structure of the adult worms, for this work is concerned more with the clinical aspects of the parasite than with the minute histology of the microfilariae, or the caudal appendages and spicules of the male, or the vexed question of the shape of the oesophagus in the different species of the genus Onchocerca. These considerations belong to the realms of those fortunate enough to be in a position to give more of their leisure and working hours to the subject than the writer.

The only characteristic which will be mentioned here is the distinguishing feature of the genus as a whole.

If/



If a piece of a cleared worm is placed beneath the medium power of the microscope it will be seen that the cuticle is raised at regular intervals into ridges which seem to pass in a circular or rather a spiral manner around the parasite. These cuticular ridges are best seen if the section to be examined is taken about the middle of the female parasite, and are often well demonstrated in stained sections of nodules using a magnification of about 500 diameters. These markings are distinctive of the genus and if seen in sections of beef in Australia are considered sufficient evidence of onchocercal infection.

# INCIDENCE OF INFECTION WITH O.VOLVULUS AND THE NUMBERS OF THE BLIND.

It has not been possible to do complete surveys of the districts in which these investigations have been carried out, but in the Zande country near Tambura about 9% of the people showed onchocercal manifestations. In the Jur country in Rumbek district the writer would put the percentage of visible manifestations as at least 60% at Mvolo, and if skin slices were examined the incidence would be much higher. If however the giant eland country is inspected, it will be found that the incidence is lower, and the blind are very few. The writer only saw three cases of keratitis whilst hunting the giant eland in the fourteen days on foot in that part of the Rumbek Jur country. In the Bellander country near Wau, Dr. A. Cruickshank estimated 4.5% of the tribe to be blind. Impairment of vision must be very much commoner and it is feared that those showing only impairment will, in the not very distant future, become totally blind.

The very significant figures given by Hissette, are worth quoting here as it appears that the country he was working in was similar to that in the Sudan where onchocerciasis is so common.

## Village:- Tangui Lonkala.

Population.	Porteurs de nodules.	Complications oculaire.	Aveugles.
Hommes - 103	98	78	24
Femmes - 108	101	81	33
Enfants - 173	64	4	4

(enfants de + de 10 ans.)

The writer sees no reason at present in view of the disquieting figures quoted in the printed part of this thesis why a similar terrible degree of impairment of vision should not exist today in some parts of Equatoria.

## Is onchocerciasis on the increase in the New and the Old World?

The writer has no doubt that the disease is spreading, and Hissette seems to agree. We both agree, and the writer has been told the same by Dinkas that/



that the coming of peace has opened up the country and now no wide tracts of land exist devoid of population, as barriers against incursion. It is interesting also to hear the Dinka theory of the coming of venereal disease. Yaws the Dinka maintain has always been present, but with the slavers came a new disease, the syphilis of the Northern Sudan and Europe, and when the Sudanese regiments came to "pacify" the country they finally established the new disease.

There seems also to be a suggestion running through the work of American observers that the disease has appeared in recent times in places where it was formerly unknown. Thus it has been suggested that the appearance of the disease in Mexico is the result of spread of the infection from Guatemala. It has been said that blindness was unknown in Mexico until 1926 and was only noticed in Guatemala in 1915. Strong contradicts this and says it was well established to his knowledge in the endemic areas, well before.

An interesting theory is put forward that the parasite was imported to the New World with negro slaves, together with Schistosoma mansoni, F. perstans, Loa-loa, and Dracunculus medinensis. The Old World may complain bitterly enough that that unspeakable curse the "chigger" is a product of the New.

In view of the suggestion put forward in the introduction to this thesis that it would be as well to look for some reservoir host, such as an antelope, domestic cattle or baboons, the observations of Cameron (1928) are interesting. Strong in discussing the possible bovine origin of onchocerciasis in man quotes Cameron who failed to find any morphological difference between O. gibsoni in West African cattle and O. volvulus from the same areas. Strong however points out that in Australia and India a heavy incidence of O. gibsoni infection in cattle is unassociated with any onchocerciasis in man.

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THE NODULE.

1. ITS SITUATION.
2. DEVELOPMENT.
3. EVIDENCE THAT O. VOLVULUS HAS A FREE FORM.
4. O. CAECUTIENS & O. VOLVULUS.
5. CLINICAL CHARACTERS OF NODULE.
6. NAKED EYE APPEARANCES OF NODULE.
7. HISTOLOGY OF NODULE.
8. IS A LYMPH VESSEL THE ORIGINAL HOME OF THE PARASITE?
9. ABSCESS FORMATION.
10. DIAGNOSIS.

## THE NODULE ITS SITUATION DEVELOPMENT & STRUCTURE.

The iliac crests, the side of the chest, the trochanters, the mastoid process and beneath the occipital protuberance are the most usual sites to find the tumours. Less commonly the acromion process, the angle of the jaw, the forehead, orbital ridges, beneath the zygoma (Hissette) and on the patella and round the knee. Text books of tropical medicine give the popliteal space as a common site, though careful search in hundreds of cases has failed to reveal a single tumour.

### TUMOUR DEVELOPMENT.

On this subject very little is known. The writer has himself watched the growth of a nodule from a little flattened, indistinct, fairly soft swelling over a rib, into the hard, bullet-like, adult fibroma-like tumour. The process took 9 months.

After much inquiry the following questions remain unanswered.

1. Is tumour formation the sign of maturity?
2. Are microfilariae or the products of metabolism responsible for the rapid growth of fibrous tissue?
3. Why should the tumours usually be multiple?  
Why not one cyst instead of thirty containing a prodigious number of worms?
4. What causes ten or fifteen worms to congregate in one place after sometimes a year in the body?
5. Has O. volvulus a free and wandering stage, or do the m.f. escaping from the biting similium remain at the site of the bite during the whole of their existence from m.f. to maturity?
6. Why are tumours usually found overlying superficial bones, instead of beneath the skin of the abdomen or in the great muscles of the thigh?
7. How long does the parasite lie dormant before it produces the fibrous tissue stimulant which promotes tumour growth? Silva (1932) records nodules appearing 18 months after removal in a patient/

patient who had not returned to an endemic area.

8. Is tumour formation essential (a) for the production of embryos, and (b) for the development of eye symptoms?
9. Is tumour formation accidental? Does it only take place when worms become entangled and their mobility impaired?

Now Cleland (1914) during his researches into the onchocerciasis of Australian cattle, found several unencapsulated worms near the hip joint of a calf. He also found one traversing a lymph gland. O. gibsoni is so like O. volvulus that there is quite a lot of doubt as to whether or not they are morphologically identical. The free forms found by Cleland were all adults. Hissette (1932), the writer and A. Cruickshank (personal communication 1934) have so far failed to find a free worm though the writer believes he extracted three members of this genus from a lion in 1935. Again these specimens together with many others which should have been available for the illustration of this thesis have gone missing owing to constant moves for relief and other purposes.

#### EVIDENCE SUGGESTIVE OF O. VOLVULUS EXISTING IN AN UNENCAPSULATED STATE.

Silva (1932) records a most interesting case seen by Toroella (1932) in which the tail of what he took to be an adult male O. volvulus was seen in the vitreous of a Mexican. The case was seen a year later and the vitreous contained refractile, golden particles, but the worm had gone. In 1933 the writer whilst working on the river Sueh with Dr. A. R. Mackelvie, saw crossing the optic disc, a highly refractile thread-like body with a closely coiled extremity. The vitreous seemed to contain fine, golden, refractile particles. There was a patch of macular retino-choroiditis. Shortly afterwards, Dr. Wilson of Cairo wrote for permission to quote this case as he had seen a similar body in the eye of an Egyptian patient. Here too a patch of macular degeneration was seen (Wilson 1933).

The case seen by MacKelvie and the writer is given in detail in the case records which accompany this thesis.

#### O. CAECUTIENS/



### O. CAECUTIENS & O. VOLVULUS.

There now seems to be a good deal of doubt as to whether these are, or are not one and the same. The evidence that they are different will be dealt with later. But whilst on the subject of the nodule, it may be mentioned that observers have attempted to distinguish between the African and the American tumour.

Thus Martinez-Baez, (1935) by comparing 2 American and 2 African nodules has laid down certain differences between the two which he maintains are characteristic. These are slight and in the fairly wide experience of the writer those features that Baez claims as peculiar to the American form have been seen repeatedly in Equatoria.

### CLINICAL CHARACTERS OF THE NODULE.

The common sites of the tumours have been mentioned already. Beneath the hand they are, as a rule freely moveable. They are very hard, sometimes feeling like a bullet beneath the skin, or like a very hard piece of rubber not unlike to the touch a syphilitic gland. A nodule may appear solitary, but as often as not it will on excision, be found to be made up of several closely adherent tumours. Those on the skull can be felt lying in a slight depression in the bone. The over-lying skin may or may not be thickened. As often as not if a nodule is carefully palpated by the finger, it will be found to be multiple.

### THE NAKED EYE APPEARANCES OF NODULES.

If a nodule is freely excised it will be seen to be surrounded by a loose almost gelatinous pseudocapsule. This strips easily revealing a smooth, white, tense, body, looking like a fibroma. Sometimes a hilum can be seen containing blood vessels and lymphatics. The writer has yet to see the perforations in the tumour wall described by Hissette (1932) and supposed to be the sites of exit for m.f. However the equipment at the disposal of that very accurate worker was much superior to that available whilst engaged on this work. Occasionally a patch resembling caseation or calcareous deposit in a tuberculous gland is seen on the surface. On section the knife creaks and grits through the tissues. In the wall of the tumour if it be solid and not cystic will be seen cut coils of worms, small blood vessels, and little areas of yellow, sandy particles. In the middle will be seen a mass of very fine filaments, - the adult nematodes./

nematodes. Exuding from the tumour will be seen a dirty, yellow, thin, almost purulent fluid. This contains cellular debris, adult and immature m.f. and ova escaped from the cut uteri of the worms. Occasionally if great care is taken, an adult male may be teased out of the tightly interwoven mass of worms.

#### HISTOLOGY OF NODULES.

The structure of the nodule differs but slightly in different cases the differences being mainly due to varying ages of nodules. The tissues and structures seen beneath the microscope may be briefly enumerated as follows:-

1. The "pseudo-capsule" consisting of areolar tissue and fibrous tissue of a very loose texture, containing m.f., eosinophiles, and large plasma cells.

2. Dense fibrous tissue, containing blood vessels, lymphatics, and occasionally a small area of calcification. Deeper in the wall a cut section of a worm will be seen. The shape of the nuclei in the wall of the worm cyst varies according to its age, being large and oval in young tumours, and thin and spindle-shaped in old.

3. Worm tunnels. These may or may not be lined with cells. In old tumours the fibrous tissue of the wall is the lining. In others, and more commonly, endothelial cells line the tunnels, and less commonly giant cells crammed with eosinophile granules.

4. Cystic spaces filled with cellular debris, giant cells in various stages of decay from cloudy swelling to disintegration. Eosinophiles, plasma cells, and coils of worms. Here too will be seen occasionally an immature m.f. escaped together with an egg or two from the uterus of the parent worm.

A typical picture cannot be given. The nodule is not only the worm's dwelling house but its sepulchre. the furnishings of its rooms an index of its affluence, the teeming occupants of its fecundity. The carpeting of the corridors, the covering of the walls and the texture of the masonry all reveal the age, and vigour or morbidity of the occupant.

#### IS A LYMPH VESSEL THE ORIGINAL HOME OF THE ADULT WORM?

If this was the case, m.f. would be found in the blood/

blood stream. The presence of an embryo in a blood film we know is a very great rarity. Now it can well be imagined that a lymphatic can contain a worm such as F. bancrofti which only measures some 3-4", but an adult female O. volvulus measures from 20-25".

Mohamed Shafi (1931) agrees with Gilruth and Sweet (1911) that the older worms by becoming sluggish and entangled cause the tumours. He believes that the fibrous tissue reaction around the parasites, and particularly the female worms, takes place in close contact with every turn and kink, and so instead of a cyst, the females become incarcerated in a maze of tunnels so tortuous that extraction without digestion of the tumour itself is impossible. Mohamed Shafi believes also that local changes in the histology of the tumour are due to the periodic escape of larvae which cause a local reaction.

#### ABSCESS FORMATION.

At Malakal a Zande patient who had been operated upon for hydrocele the fluid of which contained embryos of O.V. developed an indurated swelling in the fold between the tip of the coccyx and the buttock. He had high fever and was very uncomfortable. Thinking he had an ischio-rectal abscess the writer incised the swelling and a lot of pus was liberated. On applying pressure a mass of worms was expressed consisting of three living female adult specimens of O. volvulus. Two of these were too tangled to enable me to unravel them, but the third was undone with a pair of dissecting needles and is submitted with this thesis. The man from whom the worms were obtained said there was no tumour at the abscess site before his operation.

Strong (1934) quotes Sharp, Rodenwaldt, and Rodhain as having observed similar cases in Africa. He also mentions that Roubaud and Jamot incised an abscess in the subpubic region which contained 10 male and 5 female worms. Chesterman (1932) observed only one worm in an abscess, whilst Strong and Sandground (1934) saw only one case of a nodule which suppurated on the scalp of a Mexican.

Abscess formation may therefore be regarded as a rarity. In the case here recorded there was no evidence to show that a tumour had ever existed, as the man was in the mounted police and would have felt it.

#### DIAGNOSIS.

Van Hoof (1926), Sharp (1927) and Blacklock (1927) Strong/

Strong (1930) and the writer (personal communication to D.M.S.: Sudan Medical Service) (1932) have pointed out that O.V. nodules and the juxta-articular nodes of tertiary yaws were occasionally very alike to the touch and in their situation. We must all at one time or another have aspirated a juxta-articular nodule (particularly on a trochanter) in mistake for a worm cyst.

If aspiration with a needle fails to produce larvae, a very thin slice of skin taken with a razor and placed in saline on a slide, will often reveal embryos, especially if the skin be taken from near the tumour.

In this way sebaceous cysts, and neurofibromata may be excluded. It sometimes happens that only male worms inhabit a tumour; in which case a slice of skin will often show m.f. although no other tumours can be found.

The failure to find tumours in all cases is not remarkable when it is remembered that Hissette during his investigations found very minute tumours adherent to a piece of skin. The tumours he likens in size to grains of sorghum (Arabic, durra. The kaffir corn of South Africa), measuring only 0.82 mm-2.5 mm. Dr. Rodhain, who examined the nodules for Hissette, reported that the worms were totally encapsulated.

This last exceedingly important observation makes the mere finding of obvious tumours of less importance in doubtful cases than the examination of skin slices.

THE NON-OCULAR MANIFESTATIONS OF ONCHOCERCA VOLVULUS  
INCLUDING:-

- (1). ELEPHANTIASIS.
- (2). HYDROCELE.
- (3). "ERISIPELA DE LA COSTA".
- (4). NOTES ON THE PRESENCE OF LARVAE IN THE SKIN.
- (5). HISTORY OF THE SKIN CHANGES SEEN OCCASION-  
ALLY HISTOLOGY IN INFECTIONS WITH  
ONCHOCERCA VOLVULUS.
- (6). EPILEPSY.
- (7). METHODS OF EXTRACTION OF ADULT WORMS FROM  
NODULES.
- (8). SEROLOGICAL AND INTRADERMAL TESTS AS AN  
AID TO DIAGNOSIS.



ELEPHANTIASIS

Before discussing the dermal manifestations of Onchocerca volvulus there are two quotations which are sufficiently striking to be worth recording. The first is by Strong (1934).

"It seems evident", he writes, "that in certain individuals with higher susceptibility to the products of metabolism and to the presence and movements of the parasites in the skin, inflammatory changes and scratching of the skin may result.

In the great majority of cases of onchocerciasis in Guatemala no visible lesions of the skin are present. It is only in exceptional cases that the presence of microfilariae results in either a pruriginous or xerodermatous condition of the skin"

The second very true and picturesque generalisation is from Luna (1919). Writing of the appearances of the skin in a population heavily infected with O. volvulus he says:-

"Ainsi les jeunes avec les peaux de vieillards, les vieux avec les peaux de sauriens. C'est sous cet aspect, peut-être un peu vulgairement mais très exactement traduit, que se présente une population indigène atteinte par O. volvulus."

It will be noticed that Strong is writing of Guatemala, where elephantiasis associated with O. volvulus is almost unknown, whilst Luna writes of French Equatorial Africa a country which marches on The Anglo-Egyptian Sudan on the East, and The Belgian Congo on the South, and where like the Congo and The Southern Sudan, elephantiasis is not at all uncommon and where as far as we know Wuchereria bancrofti is unknown or exceedingly rare. er/

Luna like the Writer (1935), Hissette (1932) and Fulleborn (1908) failed to find the embryos of Wuchereria bancrofti in the French Sudan and concluded that the causal organisms were those of O. volvulus. Like the Writer he too failed occasionally to find the embryos in / er/



in very old established cases, and also recorded that sometimes elephantoid tissue was full of m.f., but no nodules could be found. This has been noticed in the Sudan on more than one occasion. Luna tries to explain some of the skin changes as being due to a superimposed infection by fungi of the epidermophyton group.

Ouzilleau (1913) working in The Belgian Congo believed the Elephantiasis to be due to the actual presence of parasites and not to bacterial infection. He failed to find F. bancrofti. He failed also in long established cases to find m.f. of O. volvulus.

Dubois (1916-1917) confirmed the findings of Ouzilleau and like all other workers up to date did not find F. bancrofti in the districts of The Haute and The Bas Ouelle.

Montpellier and Lacroix (1920), Montpellier and Beraud (1921), Montpellier Degouillon and Lacroix (1920) discuss in three very similar papers the dermal conditions which they think are due to O. volvulus. O'Neil (1875) first described Craw-Craw, and it was from this source they first realised that they were dealing with a similar condition in The French Sudan. An eruption similar to the "erisipilar de la costa" of South America, is described.

Hissette (1933) in the paper in which he once and for all shows that African and American onchocerciasis are one and the same disease, explains the rarity of elephantiasis in America by maintaining that in America the parasite for some unknown reason prefers to stay in the upper parts of the body, and in Africa, in the lower.

Schwerts (1930) in The Belgian Congo, notes that the natives call the thick, dry, itching skin, "elephant's skin" whilst as already noted the Agar Dinka call it "elephant scabies" in Equatoria. He noticed that the most heavily infected persons lived in barracks with a common verandah and the less infected in huts holding a few people only. The writer believes that had Schwerts investigated the habits of the local simuliidae more closely he would have found them to be truly domestic. The connection between the family incidence of Sudan Blindness and onchocercal manifestations in the writer's opinion is due to that insect's domestic habits. /

habits. This is a point not before noticed by other observers, and is of the very greatest importance.

Grace (1934), working on the assumption that filarial elephantiasis is the result of repeated attacks of a mild erysipelas due to hypersensitiveness to a certain organism, isolated a strain of haemolytic streptococcus (B).

He found this strain to be present in most of the cases at his disposal, and confirmed the findings of previous workers who had showed that a blockage of the lymph return due to repeated attacks of lymphangitis and not obstruction by worms was the cause of the disease.

In the elephantiasis due to O. volvulus the writer made up his mind at an early date that the disease of Equatoria was a slow process unassociated with recurrent attacks of lymphangitis seen in those cases where F. bancrofti is the exciting agent. In Equatoria a case of elephantiasis of the leg has not been seen that could not be attributed to some other and obvious cause; such as old wounds, annular ulcers of the legs, or the results of old sepsis, such as that occurring after snake bite by one of the vipers. The writer also failed to find any calcified worms, or large dilated lymphatics with thickened walls, although he has had quite a lot of material at his disposal.

It was then with special interest that the findings of Shafi Mohamed (1931) were compared with the work described in this thesis.

The pathologists in Khartoum, to whom the material was sent, reported that very marked perivascular infiltration was present throughout the sections of scrotum, that no sections of either living or dead worms were seen, that the vessels were dilated, that the lymphatic trunks appeared little changed except for the general increase in fibrous tissue in the specimen, and that microfilariae were very numerous in the thickened epithelial layers. Shafi Mohamed believes that in the elephantiasis due to O. volvulus, lymphangitis is very uncommon. He thinks that the presence of m.f. or their toxins is the cause of the perivascular infiltration and endothelial proliferation seen in the skin as well as in the sections of scrotum. He states that blockage takes place in the /

the actual lymph spaces and capillaries, whilst the large lymph vessels are patent.

The writer agrees with Ouzilleau, Laigret, and Lefrou, (1921) that m.f. are far more numerous in the skin of the scrotum than in the gelatinous mass of material which lies below.

Shafi Mohamed did not believe that a superadded bacterial infection had anything to do with onchocercal elephantiasis, but that a toxic element existed. The writer contrary to many that think that embryos are solely responsible for the pathology of oncherciasis, maintains that there is a very toxic substance produced in this condition. One has only to see the severe local reaction that sometimes takes place after the excision of tumours and the sepsis and sloughing that occasionally occurs, to realise that some pretty irritant substance has been released. Still more significant were the serious troubles experienced by Cruickshank and Cochrane in Wau (the late provincial headquarters of the Bahr el Ghazal) (1934-1935). They found in operating on the large hydroceles and scrotal elephantiasis that the patients developed very high temperatures shortly after leaving the table. There was great swelling and pain at the site of operation, and the pulse was very rapid and of poor volume. The tissues in several cases became gangrenous in a very short time and the patients died, sometimes on the third day. So serious did this become that they gave up operating on these cases altogether.

Now in the writer's experience these huge operations are accompanied with surprisingly little shock, and heal well, and skin grafts applied at the time of operation take satisfactorily. The troubles encountered by the two doctors of the writer's service are disturbing as they are both quick and experienced operators in this branch of surgery.

#### HYDROCELE.

Where oncherciasis exists, hydrocele is common in the Southern Sudan. Embryos of O. volvulus are found in the skin of the scrotum, in the fluid, and in the thickened /

thickened tunica vaginalis. In spite of careful search, an adult worm has as yet not been found. Hydrocele combined with elephantiasis is very common. No worms resembling O. volvulus have been found in the cords of hydrocele patients, but the writer found several adult female specimens of F. loa loa in this situation in the Zande country in 1933. These were the first to be found in the Sudan.

#### ERISIPELA DE LA COSTA.

Hardwicke (1928), reviewing the work of Larumbe (1926), comments that in parts of Mexico there are two diseases associated with O. volvulus, one of which is known as "mal de le ceguera" or "the blinding sickness", and the other "mal morado", or "purple sickness". The evidence that there is a distinct and separate erysipeloid condition due entirely to the m.f. of O. volvulus is conflicting. In view of the writer's own small experience of the condition under discussion, the work of Calderon (1920) is worth considering here. Calderon described an acute febrile condition involving the face and head, with swelling of the eyes, and photophobia. Symptoms were relieved shortly after removal of nodules.

Another type of case would be more chronic in character, the skin would become thick and rugose, would be itchy, and there would be exacerbation of symptoms every month or two.

Calderon's observations confirmed the findings of Robles in Guatemala in 1915 and 1919 who also noticed the association of an acute febrile erysipelas which later progressed to a myxoedematous and then a xerodermatous condition of the skin with eye symptoms and blindness. It was Robles who called the syndrome "erisipela de la costa"

The writer has had little experience of the erysipelas, but he has seen an occasional case here and there. In March 1934 an Atwot Dinka was seen at the tribal dressing station with a very swollen face, with puffy swollen eyes and the marks of scratching all over his body. My Atwot dresser immediately said. "Sir, this man has got the sickness of The Jur, he has been fishing and honey gathering in The Jur country, and has got fever of a hundred and two, and he will probably go blind /



blind. I have kept him for you here to examine". The patient (an Atwot himself) said that his swollen face was the result of the bites of simuliidae. Here again a priceless opportunity had to be foregone as I had been sent for urgently to attend to the wounded in a fight in The Alaib Dinka country. On my return four days later the man and his load of fish and honey had gone. It is worthy of note that to the casual observer the tribal dresser who recognised this case would be classed as a huge, graceful, illiterate, savage; forbidding in appearance as his shock bleached and golden hair and his bunch of large and polished spears.

"We are bitten by the flies, our faces swell up and itch, and we go blind". It may be remembered that this was the cryptic assertion of a chief in The Raik Dinka country. There can be little doubt that the Dinka have been describing in their own precise way to the writer what Robles, Calderon and Strong have called "erisipela de la costa".

Is the blindness that follows the acute febrile swelling of the face and the itching of the skin in Equatoria onchocercal keratitis, or Sudan Blindness? From the rapidity with which the blindness follows the acute condition it seems likely that it may be the latter. If this is so, one again turns to a toxic explanation, the toxin being produced:- (a) by microfilariae, (b) from the bites of a very large number of simuliidae, (c) by the adult worm.

Strong (1934) was not convinced that there was an acute febrile condition due entirely to O. volvulus, neither did Hoffman meet with it in Mexico. The writer however after fairly extensive questioning of reliable natives believes that an acute condition such as described by the workers quoted above does exist, and that it is not infrequently followed by blindness.



## NOTES ON THE PRESENCE OF LARVAE IN THE SKIN.

The writer has noticed that not infrequently a very heavily infected carrier of nodules shows no visible skin changes. The same observation has been made by Strong (1934) and Blacklock (1927). The last worker found larvae in the skin when no nodules could be found, whilst Sharp (1926) in Nigeria was able to demonstrate by skin slices that embryos were present in three times the number of cases in an infected area in non-nodule carriers than in those actually showing tumours. Reference has already been made to Hissette's view that if sufficiently thorough search is made in these instances nodules, often of very small size, will be found.

Occasionally the converse is true. Cases with well established xeroderma and pseudo-ichthyosis show no embryos in the skin; this is interesting in view of similar findings by the writer and others in cases of elephantiasis of long standing. It is believed however that if it were possible to feed simuliidae on these cases larvae attracted by the chemiotactic properties in the saliva of the insects, would be found in the mid gut on dissection. The writer thinks that embryos are not absent but scanty and as it takes a simulum a long time to scarify the skin and feed, any m.f. in the neighbourhood of the bite will be attracted and ingested.

## HISTOLOGY OF THE SKIN CHANGES SEEN OCCASIONALLY IN INFECTIONS WITH O. VOLVULUS.

In those cases in which the skin undergoes pathological changes, perivascular infiltration is again the most noticeable feature, combined with thickening of the corium. Sometimes the smooth, atrophic areas seen by the naked eye show the disappearance of the sebaceous and sweat glands and loss of pigment one would expect to see beneath the microscope. There will often be seen signs of an inflammatory exudate around the apices of the papillae, where microfilariae are numerous. Embryos will also be seen throughout the corium. It will be noted that cellular exudation has not taken place around the microfilariae.



## EPILEPSY.

It would be best before leaving the subject of the clinical manifestations of O. volvulus to mention that the writer has on more than one occasion been told that epileptiform convulsions have occasionally accompanied the onset of eye symptoms and the development of nodules. Hissette found microfilariae in the cerebro-spinal fluid of a carrier in The Congo, and the writer had a similar experience with two cases of elephantiasis on which he operated on the same day at Rumbex.

Now in the Zande country a non-familial epilepsy is not at all uncommon. It was noticed both by the writer in that area whilst relieving, and by the medical inspector in charge of the sleeping sickness camp at Tambura. We discussed the question, but as so often happens in a government service neither of us have had an opportunity to follow up the subject. This epilepsy is found in young adults many of whom are infected with O. volvulus. Further than the mere mentioning of the condition the writer is not prepared to go.

## METHODS OF EXTRACTING ADULT WORMS FROM NODULES.

Frequently it is possible to obtain complete adult males from a nodule by very careful teasing out of the tangled mass of worms with dissecting needles in saline. When it comes to the dissecting out of a very long and friable female things are very different.

Several workers have used a strong solution of papain with .2% HCl added. Cruickshank used pure papain, and the writer fed nodules to dogs that had been starved for 24 hours. This latter method had its drawbacks for if one was not bitten by the particularly savage type of vagrant cur which is so common in the Sudan, it was found when the animal was shot from 6 to 8 hours after, that fragments of bone still remained in the stomach from a previous meal, and these cut the worms to pieces.

It was found that papain alone was too slow and the solution became infected with moulds and putrefactive organisms, and little better success was obtained with hydrochloric acid. These methods are probably better suited to those workers lucky enough to have a proper laboratory at their disposal.

The /

The best and surest method is by slow and careful dissection of the worm under a low power dissecting microscope with cutting dissecting needles.

SEROLOGICAL AND INTRADERMAL TESTS AS AN AID TO  
DIAGNOSIS.

The intra-dermal injection of antigens prepared by various methods from adult worms and nodules has shown very inconclusive results. Thus Strong (1934) came to the conclusion that the antigen was toxic for uninfected and infected cases, as frequently a weal was seen in persons uninfected with O. volvulus.

Again Bennet, Strong's technician, found that using the technique of the Kahn test gave equally unreliable results with different antigens, for twelve very heavily infected cases gave negative reactions.

Rodhain and Dubois (1932), Fairly (1931), Fulleborn, (1931), found that a group reaction was obtained to various parasites such as:-  
Loa-loa, F. perstans, Ascaris lumbricoides, and strongyloides.

No personal observations have been made on the serological diagnosis of O. volvulus; the work of others is mentioned in this thesis as a matter of interest.

THE OCULAR MANIFESTATIONS OF ONCHOCERCA VOLVULUS.

Headings.

- (1) General Remarks.
- (2) Removal of tumours and improvement in eye symptoms.
- (3) Sudan Blindness and the toxic theory.
- (4) Onchocercal keratitis, and lesions of the fundus oculi.
- (5) Trypanosomiasis, Atoxyl, and optic atrophy with choroiditis.
- (6) Do microfilariae, or the toxins of the same or the adult worms have a selective action on the macula?
- (7) Onchocercal keratitis.
- (8) Onset and course of the keratitis.
- (9) Attitude.
- (10) Eyes. Appearance of, in early stages.
- (11) Corneal involvement.
- (12) Iris and pupil.
- (13) Atrophy of the iris, capsular opacity, pyriform pupil, cat's pupil, occlusio pupillae, flattening of the cornea, phthisis bulbi.
- (14) Rate of progress.
- (15) Downward deviation of the pupil.
- (16) Diagnosis of onchocercal keratitis.
- (17) Puncture of the anterior chamber.
- (18) Pathology of onchocercal keratitis.
- (19) The conjunctiva.
- (20) The cornea.
- (21) The ciliary body, iris, sclero-corneal angle.
- (22) The sclera, retina and choroid.
- (23) Note on obtaining pathological material.

# THE OCULAR MANIFESTATIONS OF ONCHOCERCA VOLVULUS.

## GENERAL REMARKS.

It is remarkable that the eye conditions associated with this parasite should not have attracted more wide attention. As late as 1932 we find Muhlens writing of the nodules; "Ils évoluent sans suite grave et avant tout sans symptômes oculaires en Afrique".

## REMOVAL OF TUMOURS AND IMPROVEMENT IN EYE SYMPTOMS.

Workers in Guatemala in the enthusiasm of their recent discoveries, believed that they had found a rapid and radical cure of the eye symptoms in the wholesale removal of tumours. Fulleborn foresaw the destruction of parasites in situ by drugs administered by some systemic route, or locally. Admitting that the alleviation of symptoms does occur for a few days after removal of nodules, he explained the improvement by what he calls an "obliterende therapie" provoked by the trauma incident to removal (Fulleborn 1932). He believes that the nodules contain toxic bodies, and the writer agrees with him, for not uncommonly a severe local and general reaction follows removal and in a fairly wide experience it has been found that healing is bad after these minor operations. Hissette (1932) like Fulleborn regards the temporary improvement to be due to an allergic reaction. The theory that the eye symptoms were due to a toxin was discredited also by Silva (1932) who like other recent observers maintained that the ocular conditions were due to the actual presence of embryos in the eye; he does not however entirely deny a toxic element.

The writer agrees with these views up to a certain point, but he thinks that Fulleborn and Hissette have been rather too pessimistic about the value of removing tumours. One cannot expect pupillary adhesions to dissolve as if by magic, or a damaged cornea to regain its former lustre, but the writer has shown that by a combination of tumour removal administration of plasmochine, and careful eye surgery, sight can be restored and improved for as long as three years at least. More important still the cases quoted in this thesis and all taken from one Jur family could none of them be called by any stretch of the imagination favourable surgical material.

SUDAN/

## SUDAN BLINDNESS AND THE TOXIC THEORY.

As far as the keratitis is concerned there is now no doubt that the toxic theory may be discarded. In the keratitis, microfilariae are found in all the structures of the eye. Cellular reaction of a perivascular nature is seen in all those structures. The media of the eye contain embryos which can be demonstrated easily as a clinical step to diagnosis. As far as is known microfilariae do not occur in the eye in the endemic retino-choroiditis of the Southern Sudan, neither does cellular reaction. The damage to the optic nerve is done rapidly and does not progress, the appearance of the fundus makes one involuntarily think of nephritis, diabetes, metallic poisons or wood alcohol. One's mind instinctively turns to a systemic intoxication. The association with Onchocerca volvulus is so close, that unless some other cause (such as the bites of simuliidae can be ascribed to the syndrome it is justifiable under the circumstances to regard Sudan Blindness as a manifestation of that nematode. But until specimens of the optic nerve can be obtained close to, or at the chiasma which show the changes seen in the nerve in the keratitis, it is permissible in the writer's opinion to consider that a toxic cause is still a possibility in Sudan Blindness.

## ONCHOCERCAL KERATITIS AND LESIONS OF THE FUNDUS OCULI.

It is a pity that Hissette did not make more use of an ophthalmoscope during his otherwise very thorough investigations. Examination of the fundus is very difficult in the keratitis, but occasionally enough can be seen in spite of opacities to show that optic atrophy, and choroiditis is often present. Not only is choroiditis seen, but large, coarse masses of pigment also which are such a typical feature of Sudan Blindness. In microscopic section however the appearances are entirely different. Occasionally a patient suffering from keratitis will complain of seeing red snakes swimming about in the water when he goes to the river. More commonly black worms are described passing before the eyes. Flashes like burning serpents shooting across the darkened hut, and other similar symptoms are described. Hissette (1931 & 1932) has also recorded these symptoms, and like the writer has attributed them to m.f. producing sensory stimulation in the nerve or macula. To date no similar history has been given by a patient suffering from true Sudan Blindness.

## TRYPANOSOMIASIS,



TRYPANOSOMIASIS, ATOXYL, AND OPTIC ATROPHY, WITH CHOROIDITIS.

Now it is well known that atoxyl used therapeutically in sleeping sickness occasionally produces optic atrophy. It is thought that some damage to the nerve has already been done, and that the toxic drug just pushes the none too healthy nerve over the edge, as it were. The writer has seen quite a number of cases that have gone blind after a prophylactic dose of this drug. Very careful histories were taken but all that was complained of was a steady loss of vision without other symptoms. The ophthalmoscope revealed an ordinary optic atrophy in all cases.

Larumbe (1926) working in South West Mexico reported that in Chiapas 4,000 cases of onchocerciasis were examined of which about 800 had developed keratitis, CHOROIDITIS, and iritis, and a hundred were totally blind.

Hissette (1932) however may be quoted to the contrary. On page 50 he writes:-

"Comme on le remarque, souvent la pupille est en myosis mais il existe des cas où la pupille est en mydriase, et où la k ratite ne s'aper oit pas   l'oeil nu, ou fait d faut; ces cas, d j  vu par des observatoires am ricains dans l'onchercose   caecutiens sont quelque fois confondus au Congo chez les sommeilleux pour de l'amaurose due au traitement par les ars nicaux. Je crois qu'il est utile de mentionner ce fait, car j'ai pu me rendre compte que des erreurs avaient  t  quelques fois comprise en ce sens. La discrimination est cependant simple par l'examen du fond de l'oeil, qui montre de l'atrophie de la papille dans les cas o  l'amaurose est due au traitement ars nical ou   la trypanosomiale".

"Dans l'Onchercercose oculaire, l'examen du fond de l'oeil ne montre pas d'atrophie de la papille".

With the last statement the writer must disagree; optic atrophy has quite often been seen where it has been possible to get a view of the fundus in cases of keratitis, as also has choroiditis. The dilated pupil, and absence of corneal opacity in the cases mentioned by Hissette in the quotation above are suspicious. Has Hissette been seeing cases of Sudan Blindness as well as cases of optic atrophy due to atoxyl?

Did Larumbe see in Mexico the retino-choroiditis here/

here described and attribute it at once to O.V.? Or were his cases of choroiditis combined with keratitis like case No.5 of the series suffering from definite corneal involvement submitted with this thesis?

DO MICROFILARIAE, OR THE TOXINS OF THE SAME OR THE ADULT WORMS HAVE A SELECTIVE ACTION ON THE MACULA?

It is known that the microfilariae of Onchocerca volvulus are phototaxic. In quite a number of cases of Sudan Blindness there will be seen a patch of macula chorioiditis and not a great deal of change elsewhere. The same can be said of those eyes that enable one to see the fundus in spite of opacities in keratitis. It seems possible therefore that since the maximum of light impinges on the macula that a congregation of microfilariae at that point might cause the lesions. Against this m.f. have not yet been found in an eye showing the signs of Sudan Blindness.

#### ONCHOCERCAL KERATITIS.

Robles (1916) first called attention to the ocular complications of Onchocerca volvulus in Guatemala, his observations being confirmed and enlarged upon especially by Luna (1918 & 1921) and Calderon (1917 & 1920). These investigators were over optimistic in their belief that removal of tumours was followed by rapid and complete recovery in many cases. They believed the lesions to be due to a toxin produced by the adult worms. Brumpt (1927), Muhlens (1932), and Blacklock (1927) failed to associate eye symptoms with O.V. nodules, in Africa.

Ouzilleau, Laigret, and Lefrou in 1921, Clapier in 1927, Rhodain in 1920, and Laigret in 1929, reported a few cases from Africa which they never definitely proved to be due to Onchocerca volvulus. For the complete description of the African disease we are indebted to Jean Hissette who in 1932 published a very full memoir on the subject including the pathological findings in the eyes he removed during his investigations.

The writer was able to confirm Hissette's findings whilst working in Equatoria in 1932 and 1933.

#### ONSET AND COURSE OF THE KERATITIS.

The patient first complains of a dryness of the eyes. This is soon followed by lachrymation and photophobia. Pain now often becomes very severe indeed, /

indeed, and the writer has seen a full grown man shaking his head in agony. He has also seen two cases where the acute onset has been accompanied by epileptiform convulsions, and a patient who many years ago during the beginning of the disease had fallen in the fire and severely burnt himself. Bi-temporal headache is often complained of, and the actual pain in the eyes is likened to thorns piercing the eye ball, intense burning as if chillies had been rubbed into the eye, red hot snakes running about beneath the lids, and other similar descriptions.

#### ATTITUDE.

The attitude of the patient during the onset and whilst the disease is progressing is very typical. At a meeting he sits in the deepest available shadow shielding his eyes against the glare with his hands, and when addressed peeps up at the speaker, his eyes pouring with water, whilst the side of his nose is covered with scales of salt from the drying tears. Others merely hang their heads and look at the ground the water running off the tips of their noses or falling vertically from their lids, and look at their interrogator with screwed up eyes and distorted faces.

#### EYES. APPEARANCE OF IN EARLY STAGES.

It is best when examining the eyes in the early stages to cocaineise them with a drop or two of 2% pantocaine containing a little adrenaline. Now in most inflamed eyes the congestion of the conjunctiva soon vanishes with this treatment. In the beginning of onchocercal keratitis the conjunctival vessels will be seen to become much less engorged but a dull pink will be seen to persist and no amount of adrenaline will make it disappear. This is the "rougâtre livide" of Hissette. The lividity is most marked around the sclero-corneal junction. If the limbus is pressed even with the eye well cocaineised pain will be felt. This seems to suggest that the junction of iris, sclera, choroid and ciliary body are involved very early on. This is interesting because in spite of the acute symptoms at the onset, corneal sensibility is actually diminished. At the very commencement of the disease there is very little else to note.

#### CORNEAL INVOLVEMENT.

If the inferior edge of the cornea is examined, very small, pearly grey opacities will be seen; at the/

the equator too, the same spots may be found, and it may be noticed that there is an increase in vascularity around the cornea's lower edge, and a few small vessels will be seen invading the lower edge. The conjunctiva is looking rather thickened around the limbus and especially at the horizontal equator where it may encroach slightly on the cornea like a pterygium.

### THE IRIS AND PUPIL.

The little grey opacities increase in size and number, many become confluent and the cornea is losing its lustre. If the area of punctate keratitis is carefully examined with an oblique light, it will be seen that there is a crater-like depression over each spot. If however a drop of fluoresceine be dropped into the eye it will be found that there has not been a loss of surface epithelium but a loss or shrinkage below, and that the depressions are not ulcers. This phenomenon will be discussed with the pathology of keratitis.

It will be found now that the lower edge of the pupil is adherent to the anterior capsule, and that a grey atrophic rim has formed along that adhesion. The structure of the iris in its lower half is not so distinct and the crypts have areas of greyish degeneration around them. If atropine is instilled dilatation is sluggish, the pupil is irregular, crenated, or shows a colomba.

### ATROPHY OF THE IRIS, CAPSULAR OPACITY, PYRIFORM PUPIL, CAT'S PUPIL, OCCLUSIO PUPILLAE, FLATTENING OF THE CORNEA, PHTHISIS BULBI.

The anterior chamber now becomes deep, the intraocular tension is apt to rise, the lower 1/3rd of the cornea is a dense leucoma irregular in opacity and colouring. The limbus has a deep pigmented edge and there are spots of pigment in the conjunctiva. Previous observers do not seem to have noticed the deposit of migratory pigment around the limbus, but it is often seen at quite an early stage.

The pupil is very drawn down and will not react to atropine. If a view of the fundus is possible and the media have not become too opaque the disc may appear normal, but it is more likely to be pink and inflamed or even atrophic. Black pigment may be seen on the fundus and some choroiditis.

The pupil passes from the pyriform to the slit-like, the lens capsule is quite opaque. The lower end of the elongated pupil becomes adherent to the back of the/

the cornea as well as to the anterior capsule. The anterior chamber becomes progressively shallower as the leucoma advances upwards, and the cornea starts to get flat. Phthisis Bulbi ends the picture.

#### RATE OF PROGRESS.

Hissette lays a good deal of stress on the slow progress of the disease but the writer has often seen the keratitis progress very rapidly. However he may have been dealing with people more susceptible or a more virulent parasite. A Jur man with whom the writer used to hunt went blind in 6 months. The pupil changes must have come on very rapidly but with treatment quite a fair degree of vision has been restored to him and he was able to follow buffalo with the writer this year into uncomfortably heavy cover.

Hissette has tried to divide the progress of the condition into stages. Convenient as this may seem in theory, it must be remembered that this is a progressive disease in which the corneal damage may predominate over the iridocyclitis, and vice versa. Or perhaps mild changes in the front of the eye may be overshadowed by changes in the optic nerve, macula, retina and choroid. It has therefore been considered in this description that a brief outline of the course of the disease on general lines would give a truer picture of a pathological process than a carefully arranged table of events.

#### DOWNWARD DEVIATION OF THE PUPIL.

The downdrawing of the pupil is a very typical feature of Onchocercal keratitis once it has been fully established. Torocella did not notice this sign and recorded his failure to find it. Hissette expresses some surprise at this statement and says that it is almost universal in cases of keratitis in the Belgian Congo. In the Sudan as in the Congo it is very common.

#### DIAGNOSIS OF ONCHOCERCAL KERATITIS.

There are very few conditions that cause a keratitis of the lower edge of the cornea. The most likely one to be encountered is that caused by placing some irritant substance beneath the lower lid. Consequently an opacity in this situation is not uncommonly seen in eyes that have been treated by a native remedy administered by a kajour. In India a flake of lime/



lime is sometimes dropped into the eye by malingerers who wish to evade work or military duty. Short of these two a keratitis in the situation of that seen in onchocercal lesions is very rare.

Trachoma usually causes ulceration at the centre or upper part of the cornea. The pannus which follows trachoma is not confined to the bottom of the eye. The lids in the onchocercal condition do not show the scarring of old or the granulations of new trachoma.

Trichiasis in the Southern Sudan is not caused by trachoma to nearly the same extent as in Egypt and the Northern Sudan. Amongst the Nilotic tribes such as The Nuer, Dinka, Shilluk, and Anuak, trichiasis is appallingly common and with cataract is the cause of most of the blindness. It is thought that the chronic irritation caused by the blowing cow dung ash of the great cattle camps, combined with the infection spread by the swarms of flies gives rise to a chronic blepharitis which eventually causes trichiasis. The writer believes that in the past the opacities due to onchocerciasis have been overlooked as it was thought they were due to the usual cause of chronic irritation.

Measles in children is a very common cause of blindness, so much so that many Dinka mothers tie the hands of their children to their sides, or wrap the hands in skins during the illness to prevent them scratching their eyes. Here again the opacity is circular and central, and is very often associated with a staphyloma. The writer has never seen a staphyloma in a case of onchocercal keratitis.

Small pox as a rule leaves a single, dense, circular central leucoma in no way resembling onchocercal keratitis.

Injuries from grass and thorns are nearly always central.

Interstitial keratitis due to syphilis is far too diffuse to be mistaken for the disease under discussion unless it is of very long duration.

#### PUNCTURE OF THE ANTERIOR CHAMBER.

The presence of microfilariae in the anterior chamber is diagnostic. Hissette and other workers snip out a piece of bulbar conjunctiva, keep it near 97 degrees C in a spot of saline and examine under the low power of the microscope. With all due deference to/

to the distinguished body of scientists who have worked on the subject, the writer affirms that the presence of embryos in the conjunctiva quite often occurs with no ocular manifestations. Microfilariae in the aqueous however always means pathological change.

Puncture is performed as follows. Instil a few drops of 2% pantocaine. Insert a self retaining eyelid retractor. Grasp the conjunctiva and pull the eye downwards with a pair of fixation forceps. It is more convenient to use a long narrow tuberculin syringe and very fine platinum needles. Pass the needle into the anterior chamber as if inserting a cataract knife using the left hand for the left eye, and the right for the right. The aqueous so extracted is placed on a slide with a coverglass in position and if present embryos are easily seen owing to their size and motility. The aqueous will often be seen to be of a pale yellow colour, and contains many cells.

Suspicious nodules can be punctured, and skin scrapings and slices taken and examined for embryos also as aids to diagnosis.

#### THE PATHOLOGY OF ONCHOCERCAL KERATITIS.

Histologically the key notes of this condition are an increase in the number of blood vessels around the cornea, a vascularisation of that structure and perivascular infiltration or "cuffing" in all the vessels of the eye. Microfilariae can be demonstrated as a rule throughout the uveal tissues. Occasionally in a very advanced case of long standing the embryos of O.V. are absent having died out, leaving the typical picture of the disease behind them.

#### THE CONJUNCTIVA.

The changes seen in the conjunctiva closely resemble those seen in the skin, but are confined as a rule to the tissue bordering the limbus. The vessels are engorged and numerous and show distinct cuffing, the exudate being mainly composed of small round cells, eosinophiles, a few polymorphs, and a plasma cell or two. In the deeper layers of the membrane will be seen masses of migratory pigment. (cf. field sketches and remarks in the clinical description of the condition.) Microfilariae are seen in the tissues but as in other situations display no cellular reaction around their bodies. They are most numerous near the limbus.

THE/

THE CORNEA.

The cornea like the brain has no lymphatics, and it is interesting to note the very marked perivascular infiltration around the vessels in the diseased layers. The cuffing is as marked as that seen in sections of brain from advanced cases of trypanosomiasis. The new vessels advance from the limbus between Bowman's membrane and the epithelial layers of the cornea, embryos can be seen between those layers surrounded often by clear spaces of their own making. The surface epithelium will be seen to be intact in some places where there is a distinct depression caused by the contraction of scar tissue in the deeper layers. (cf. crater-like depressions on cornea resembling ulcers mentioned in the clinical observations). In some places the surface epithelium is heaped-up and hypertrophic.

Bowman's membrane is intact at the beginning but gradually becomes destroyed in the steady progress of the disease. The central layers become vascularised, cuffing being a marked feature, the presence of fibroblasts is more noticeable, but giant cells are not seen as one might expect had one been dealing with the infective granulomata.

Separation of Descemet's membrane, which becomes folded on itself, occurs early.

THE CILIARY BODY, IRIS, SCLERO-CORNEAL ANGLE.

The ciliary body is involved early on. Fibrosis and the outpouring of a serous and cellular exudate distort this structure which soon becomes atrophic. Microfilariae are seen in its substance.

The iris as one would expect from the clinical observations already recorded shows cloudy swelling of its surface endothelium as a rule at an early stage, thus explaining lack of definition of the structure of iris when examined with the naked eye. The reticular layer shows a rarefaction of pigment in some places and heavy conglomerations in others, whilst on the whole the tissue is swollen and oedematous. Microfilariae are most numerous in the sclerosed and atrophic pupillary border which in a well established case will be seen adherent to the thickened anterior capsule by a fibrinous exudate containing embryos. The atrophy surrounding the crypts which is so commonly seen in clinical examination is a very typical feature of the pathology of the iris.

As/

As the process advances the angle between the sclera and cornea becomes filled with exudate containing microfilariae.

The writer like Hissette has found that the iris becomes exceedingly friable at a very early stage in those cases where an iridocyclitis is more noticeable than keratitis. Thus like the Belgian observer he has found that in performing an optical iridectomy it is difficult to obtain a satisfactory section of the iris, which tears in the forceps before it can be drawn out of the wound.

#### THE SCLERA, RETINA, AND CHOROID.

The sclera is as a rule unaffected except at the sclero-corneal junction where the usual perivascular infiltration will be seen with an increase of vascularity.

The choroid again shows hyperaemia, cuffing of vessels and the presence of parasites. There is depigmentation in some places with atrophy of the epithelial cells bearing the pigment. Between the vessels will be seen a certain amount of fibrinous exudate.

The retina according to Hissette shows signs of inflammatory change with occasional haemorrhages. The writer has seen very marked exudation in the retina the various layers becoming fused and indistinguishable. Parasites are most likely to be found near the optic disc, but are not usually seen.

The optic nerve according to Hissette shows the most marked changes in the retro-bulbar part where glial proliferation, the presence of parasites, and marked perivascular cuffing are seen. He notes that the main arteries and veins are very dilated but keep their normal relations to one another.

The vessels in the orbit share in the vascular changes seen in other parts of the eye and are sclerosed.

#### NOTE.

In a country where autopsies are very seldom obtainable it has been nearly impossible to get pathological material. The constant moves that occur in a government service have led to the three eyes that were to be used for the illustration of this thesis to be/

be lost together with the slides and paraffin blocks. The only eye that is available is one in the laboratory of the Royal College of Physicians of Edinburgh in the care of Colonel Harvey. This specimen is one showing very advanced changes and no parasites are present. In the two eyes obtained showing the changes seen in Sudan Blindness, only a very small piece of the optic nerve was removed as enucleation was performed in a hurry before the patients had time to change their minds, and the scissors used were not sufficiently curved and were far too large to get good access to the orbit.

It is of interest that in the districts where this work has been done it was found best to offer to buy the material needed. The purchase of a blind eye as a rule demands the expenditure of about the equivalent of fifteen shillings. This is paid in cash, partly in goods such as a number of spears equal to the price of a wife, and the rest in cash, or entirely in goods, a bag of salt, a shirt, marriage spears, packets of fish hooks and so much sugar.



in Africa, and that he named the New World form *O. caecutiens*. As to morphology, J. H. Sandground,<sup>3</sup> after examination of onchocerca worms from various sources in impressive numbers, has found no constant difference between those from Guatemala and those from Africa, while as to lesions, the facts quoted above show that the production of ocular lesions does not, in fact, distinguish from one another the forms found in the two hemispheres. *Onchocera volvulus* is, then, the valid name for this parasite of man. What causes it to produce in certain parts of the world these devastating effects on the eye is unknown. Richard C. Strong<sup>3</sup> notes that in Guatemala, which place has given the worm its title of "blinding," only 5 per cent. of the infected suffered from ocular lesions. In the affected spots in the Sudan, however, the percentage of infected so suffering is clearly many times greater, and is showing a disquieting rate of increase. Accordingly the obligation on its Government to take active steps for the closer investigation and stronger control of this infection is of corresponding and pressing urgency.

### THE LAURENCE-MOON-BIEDL SYNDROME

THE association of obesity, hypogenitalism, mental retardation, and polydactyly with retinal pigmentation may at first sight seem at least as improbable as the existence of Othello's men whose heads do grow beneath their shoulders. On embryological grounds it is hard to link the mesenchymal abnormality which results in the polydactyly and other skeletal defects with the retinal and diencephalic defects which are epiblastic in origin. The complete syndrome is, indeed, of extreme rarity, and in some of the family groups recorded is only seen spread through different members of the family. Cockayne, Krestin, and Sorsby<sup>4</sup> have reviewed the literature of this curious condition, adding two family groups to the 30 or so examples already published. Out of the first family group of ten, three (and possibly four) members were found to be affected, whilst of the second group of four members three were affected. In the first instance no one patient showed the full syndrome, although all the components of the syndrome were found between the three affected patients. In the second group the eye changes were those of cerebromacular disease. The authors discuss the possible relationship of the condition with juvenile amaurotic idiocy (Batten-Mayou disease), since certain characteristic eye changes may occur in both; but there are, as they point out, definite differences in the onset, course, neurological signs, and sex incidence, there being an excess of males affected with the Laurence-Moon-Biedl syndrome, whereas no such preponderance exists in juvenile amaurotic idiocy. They also conclude from the evidence available that the Laurence-Moon-Biedl syndrome is inherited as an autosomal recessive. In the complete sibships recorded, information as to the presence or absence of consanguinity of parents is given in 23 instances; of these, 6 were the result of first-cousin marriages and 3 of second-cousin marriages, whilst in the remainder there was no blood-relationship. Thus 43 per cent. were derived from first- or second-cousin marriages. There is no instance of the parents being affected with the syndrome. The authors also incline to the suggestion made by Rieger and Trauner<sup>5</sup>—

<sup>3</sup> Onchocerciasis, with special reference to the American form of the Disease. Contributions from Dept. of Trop. Med. and Inst. for Trop. Biol. and Med. (Harvard Univ.), No. 6. London: Oxford University Press, 1934. Reviewed in THE LANCET, March 23rd, 1935, p. 689.

<sup>4</sup> Cockayne, E. A., Krestin, D., and Sorsby, A., Quart. Jour. Med., April, 1935, p. 93.

<sup>5</sup> Rieger H., and Trauner, R., Zeits. f. Augenheilk., 1929, lxxviii., 235.

ENDEMIC RETINO-CHOROIDITIS IN THE ANGLO-EGYPTIAN  
SUDAN AND ITS POSSIBLE RELATIONSHIP TO  
*ONCHOCERCA VOLVULUS*.

BY

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During the winter of 1931-32, the writer had brought to him a native boy who was completely blind. The ophthalmoscopic appearance of the fundi was most unusual, and on enquiry it was found that large numbers of the tribe to which the boy belonged were also blind. Further investigation showed that throughout the Bahr-el-Ghazal Province of the Anglo-Egyptian Sudan blindness, night blindness and defective vision were appallingly common, and that the bulk of the cases examined were suffering from a gross form of retino-choroiditis associated with optic atrophy.

GEOGRAPHICAL DISTRIBUTION.

It was then found that the blindness was local in its distribution, the foci of disease being in certain circumscribed areas, usually along the banks of rocky streams and most commonly in forest country. Many of these streams join the great western tributary of the mountain Nile, the Bahr-el-Ghazal, others such as the Yei, the Naam and the Meridi river or Gel are lost in the immense swamps of the Sudd region of the Upper Nile.

In their upper reaches they are rapid, their courses rocky and their banks heavily clothed in forest; lower down they are sluggish and in the dry season represented by a series of long deep pools. Their banks are sheer and bare of forest, the country through which they run is flat and grassy and in the rains

\* I wish to thank Dr. J. HISSETTE for his suggestion that Sudan blindness might be due to *O. volvulus*. It was through this that the parasite was searched for and found by the writer.

To Dr. A. R. MACKELVIE, Ophthalmic Surgeon, Sudan Medical Service, I am specially indebted for his kind help, and the interest he has shown in this work, and for his examination of many of the cases.

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## THE HISTORY OF ENDEMIC BLINDNESS IN THE BAHR-EL-GHAZAL PROVINCE.

In 1911 a note appears in the Province Diary that elephantiasis, hydrocele and night blindness are common in the country around Wau—the provincial headquarters. As far as is known, until the writer's report to the Director of the Sudan Medical Service in 1932 the condition had not previously been described.

Between the years 1869 and 1871 SCHWEINFURTH (1873) travelled through most of the Bahr-el-Ghazal. His description of the habits of the people and his sketches are excellent, and if the disease had been as common in those days as it is to-day, it is hardly likely that such an acute and accurate observer would have failed to notice it.

Thus south of Wau a section of the Bellanda tribe is now badly affected. These people state that until 7 years ago the disease was rare. The Government then moved the tribe to their present quarters on the River Sueh, and from that day onwards the disease has become very common. The Senior Medical Inspector, Bahr-el-Ghazal Province (CRUICKSHANK, 1934) estimates that 4.5 per cent. of the whole tribe is totally blind.

Among another tribe on the Lau river in Yirrol district, 8 adult Dinka taxpayers out of 100 have been exempted from taxes owing to blindness contracted during the last year. Among these people the disease was unknown until 1933.

On the Tonj river amongst the Dinka people at Wan Alel no case of retino-choroiditis or onchocercal keratitis was seen with a history of more than 3 years' duration.

Amongst the Rumbek Jur the disease has always been present, but about 1910, when the Lado Enclave was being handed over to Anglo-Egyptian administration, a large raid by the Azandi took place, and it is from this date that the Jur believe that the number of blind started to increase. The writer has been told by the old men of the tribe that Simuliidae are much commoner now at Mvolo on the Naam river than they were 30 years ago. They maintain, however, that in the year in which the raid took place the swarms of this insect exceeded in numbers anything seen before or since.

It seems then that an endemic disease which has been present in the Bahr-el-Ghazal Province for many years, certainly since 1875 if Azandi data given by the very old men are reliable, has now become epidemic.

As an example of the serious nature of the epidemic disease the following instances may be quoted. 8 blind people out of a family of 13 were seen in 1932 on the Naam river: the family belonged to the Jur tribe; 14 persons were blind in a colony of 21 inhabiting four huts near Wau; 4 people were blind in a family of 6 in the Raic Dinka country in Tonj district. Most of these cases were due to retino-choroiditis, but some were definitely due to onchocercal punctate keratitis. As will be seen later, the aetiology of these two diseases is very similar.

## CLINICAL AND OPHTHALMOLOGICAL SIGNS OF SUDAN BLINDNESS.

The following case was the first seen, and is typical of the disease from its onset with lachrymation to its termination in total blindness.

JUR BOY, aged 12. Rumbek District, Bahr-el-Ghazal. Blind for 3 years.

The disease started as "a swelling of the eyelids and a running of water from the eyes during the sowing of the durra" (June).

The watering and discomfort continued for some time (probably 2 or 3 weeks) and then ceased. He then found that he stumbled over fallen boughs of trees, ran into ant-hills and had great difficulty in distinguishing near objects when the sun went down but whilst it was still light. By the time the durra was well up (August) he was completely blind. When examined he could just see the open door of the hut.

*Family history.*—Nothing to note. No other cases of blindness in family.

*General Examination.*—No abnormality of any sort was found, the boy was well grown and well nourished. His teeth were perfect, no swellings were found on his ribs or iliac crests.

Owing to an eosinophilia of 10 per cent., stools, blood and urine were examined: no ova, blood, albumin or sugar were found.

*Eyes.*—General appearance normal.

Pupils rather large and equal, cornea clear, conjunctiva normal; light reaction very sluggish.

*Lids.*—Normal. No signs of trachoma or yellow nodules or thickening described in the disease called "bulge eye" in Uganda.

Instillation of 1 per cent. atropine sulphate produced wide and equal dilatation of pupils.

*Ophthalmoscope.*—All media clear.

Discs very pale except for pink tinge around entrance and exit point of vessels. No cupping. Well marked high light along anterior surfaces of retinal vessels. No haemorrhages. No diminution in size of retinal vessels.

*Fundi.*—The most noticeable feature of both fundi was the amount of pigment scattered over the retina, and in and around the large white patches of exposed sclera that were sometimes crossed by a retinal vessel.

The retina was extremely thin and transparent so that the choroidal vessels could be plainly seen, and these, becoming brightly illuminated gave a most peculiar appearance to the fundus.

## PLATE I.

FIG. 1.—The fundus in a case of Sudan blindness showing:—

- a. The pallor of the optic disc.
- b. Large patches of pigment lying on the retina.
- c. Rarefaction of the retina.
- d. The brightly illuminated choroidal vessels shining through the retina.
- e. The irregular, rough, unevenly coloured fundus. (Photograph of a sketch in oils taken during life.)

FIG. 2.—Skin as sometimes seen in onchocerciasis giving the impression of great age owing to thickening and loss of elasticity. Note the tumours of *O. volvulus* lying over the ribs.

FIG. 3.—From water colour sketches of eyes of patients suffering from onchocercal keratitis, showing:—

- a. The opacity of the lower half of the cornea.
- b. The irregularity in colouring and density of the opacity.
- c. The piriform shape of the pupil which becomes still more drawn down by anterior and posterior seneschia, later becoming slit-like and finally obliterated.
- d. The greater density of the deposit near the horizontal equator of the cornea.



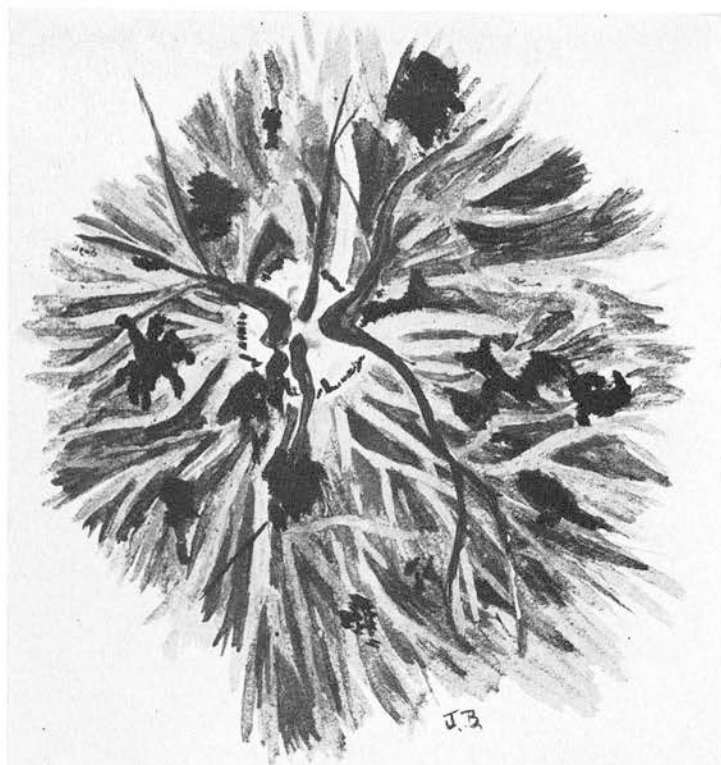


FIG. 1.

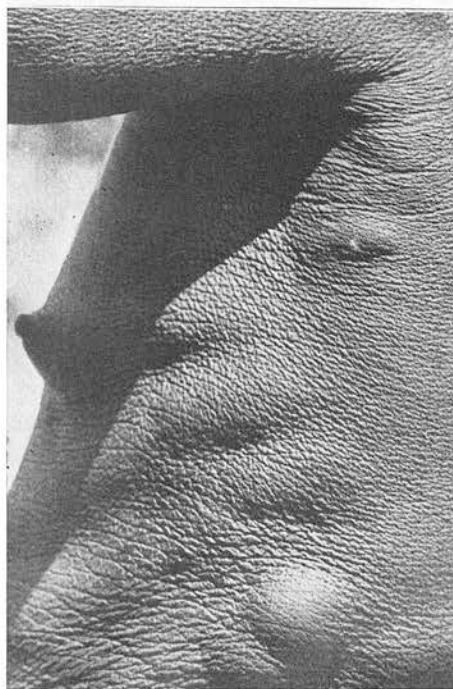


FIG. 2.



FIG. 3

PLATE I. (For description see opposite page).



FIG. 4.

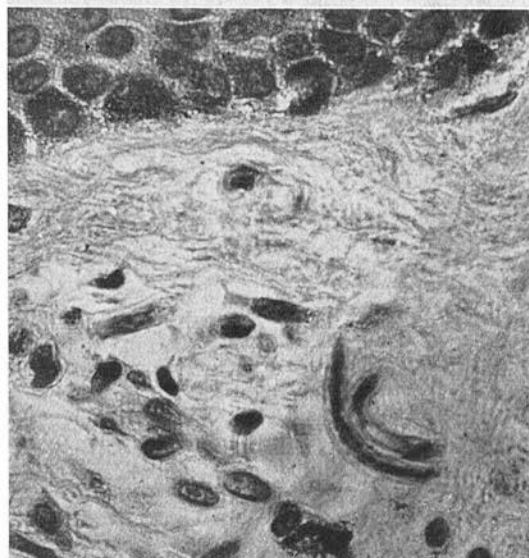


FIG. 5.

## PLATE II.

FIG. 4.—Fundus of the eye in Sudan blindness. Specimen from patient from whom the ophthalmoscopic sketch in Plate I, Fig. 1 was made.

### Note :

- a. The absence of inflammatory reaction in choroid, sclera or retina.
- b. The absence of perivascular cellular reaction.
- c. The diminution in the number of the layers of the retina.
- d. The passage of a mass of pigment through the retina to near the surface. The pigment in this instance is clumped around a small vessel.

Haemalum and eosin :  $\times 120$ .

FIG. 5.—Skin from the same case as in Fig. 2.

Embryo of *O. volvulus* lying beneath the epithelial layers. Note the absence of cellular reaction around the parasite.

Haemalum and eosin :  $\times 750$ .

As a result of information received, a rapid trip was made into the Rumbek Jur country where 47 cases were seen, 30 being examined by the ophthalmoscope.

The typical syndrome may be described as follows :—The onset is in the early rains with lachrymation and a mild irritation of the conjunctiva and photophobia. Cessation of lachrymation is followed by rapidly increasing night blindness. Blindness either becomes complete in 2 to 5 months from onset, or the patient suffers from seriously impaired vision and night blindness. Very marked changes occur in the retina and choroid with optic atrophy. The amount of destruction visible by the ophthalmoscope is no index to the impairment of vision. The grossest lesions are occasionally associated with fair eye-sight and the milder fundus changes with complete blindness. The cornea is nearly always clear, but posterior seneciae are not uncommon. The pupils are usually very sluggish and half dilated. Microfilariae of *O. volvulus* are absent from the anterior chamber on aspiration with a fine needle. (In *O. volvulus* keratitis, microfilariae were always present in the cases examined up to date). Sudan blindness is, as far as is known, always bilateral. (Onchocercal keratitis is occasionally unilateral).

#### *The appearance of the fundus in Sudan Blindness.*

The most noticeable feature is the "rough" appearance of the fundus, due no doubt to the irregularity in the thickness of the retina. The choroidal vessels are often plainly seen. Occasionally patches of sclera can be observed surrounded by black masses of pigment and the optic disc is usually chalky white, but often retains a pink tinge around the meeting point of the vessels.

The colour of negroid fundi varies a great deal in people of the same tribe. The distribution of the pigment is irregular; sometimes large masses lie on, and conceal the retinal vessels, or it may be that the pigment is finely divided and widely scattered. The retinal vessels not infrequently show considerable sclerosis. There is no very special age factor. Recently contracted Sudan blindness has been seen in children of 7 to 11 years and in men between 50 and 70. Women are less commonly affected than men, both with keratitis and Sudan blindness.

#### *Pathology of Sudan Blindness.*

Pathological material has naturally been hard to obtain. Two eyes were removed, however, after the fundi had been sketched (see Plates I and II) and the microscopic appearances are briefly as follows.

- (1) Irregular atrophy of the layers of the retina, especially the layer of nerve fibres and diminution in the number of cell layers.
- (2) The presence of masses of pigment lying on the retina or in its substance.
- (3) An increase in the number of vessels in the retina. These have no cellular reaction around them.
- (4) The absence of microfilariae in any structure of the eye.

(5) The absence of inflammatory reaction in choroid, ciliary body or cornea.

The microscopic findings in the two eyes removed differ entirely from the changes throughout the eye seen in onchocercal keratitis, which are

(1) Vascularisation of the cornea with the presence of microfilariae between the corneal layers,

(2) Cellular reaction due to plasma cells around the vessels in sclerotic and choroid, and the marked inflammatory and fibrotic changes in the ciliary body,

(3) Perivascular cellular infiltration of the vessels in the optic nerve,

(4) The presence of microfilariae throughout the eye.

#### POSSIBLE CAUSES OF SUDAN BLINDNESS.

Of the possible causes of Sudan blindness organic poisons may be excluded as the disease occurs in a few places in the Dinka country where no poisons are used, and the same is true of fish poisons, such as *Randia nilotica* which is regarded by the natives as a probable cause. Antimony is not used as a cosmetic in endemic areas. Nephritis and diabetes are not connected with the disease and the foci of endemicity are so restricted that yaws, which is widespread, cannot be an aetiological factor. Cassava, the root of which eaten in excess is said to produce a retrobulbar neuritis in West Africa, is not grown in all endemic areas. Heredity does not appear to play any part in the aetiology of the disease nor does consanguinity. Famine and vitamin A deficiencies are not common in the areas where Sudan blindness is endemic.

There remains the possible association with *Onchocerca volvulus*.

#### *Manifestations of Onchocerca volvulus.*

Where manifestations of this filarial worm have been noted, there also has Sudan blindness been found; and where it is most common, there also have most cases of Sudan blindness been seen. Amongst 750 adults paraded for sleeping sickness inspection, 9 per cent. showed manifestations of *O. volvulus* such as thickened skin, tumours, keratitis, hydrocele or elephantiasis. These last two conditions are included here because, up to the present, *Filaria bancrofti* has never been demonstrated in them. Whilst admitting that this does not exclude *F. bancrofti*, it is remarkable that persons suffering from elephantiasis have hitherto been found to be heavily infected with *O. volvulus* and the microfilariae have been found in swarms in elephantoid tissue, in scrapings from hydrocele sacs and in hydrocele fluid. The places where nearly all the cases of elephantiasis are found are those where *Simulium damnosum* exists.

A number of cases of Sudan blindness were found and these showed 58 per cent. of visible manifestations of *O. volvulus* or 49 per cent. more than the average incidence in the adult population. Skin scrapings were not done.

From its aetiological and geographical association with *O. volvulus* and the frequency of its occurrence together with the obvious naked eye manifestations of that parasite, one cannot help considering that Sudan blindness is an ocular manifestation of *O. volvulus*.

Onchocercal tumours are commoner in adults than in children, and in old people than in young adults. The same can be said of *Filaria perstans* infection, some 5 per cent. of children from 5 to 10 years being infected, whilst 80 to 90 per cent. of adult males and females are infected in the Rumbek Jur country.

As a matter of interest the anterior chamber was aspirated and the aqueous humour examined from fifty natives with normal eye-sight, but heavily infected with *O. volvulus*. No microfilariae were found.

Up to date microfilariae have been found in the aqueous fluid in every case of keratitis examined, but they have never been found in the aqueous fluid of persons suffering from typical Sudan blindness. Puncture and aspiration is performed under 2 per cent. pantocaine, using a tuberculin syringe. If present, microfilariae are easily found with the lower powers of the microscope, owing to their size and motility. The cell content of the aqueous fluid is much increased.

This has been found to be a quicker and less disturbing method than that used by HISSETTE and others of snipping out a portion of the bulbar conjunctiva and teasing it out before examination in saline. HISSETTE records that in the Belgian Congo the natives associated blindness with *Simulium*, and this is also true of the Anglo-Egyptian Sudan. The establishment of peace by breaking down intertribal barriers may have increased the infected areas as suggested by HISSETTE (1932).

#### *Points of Contrast between Sudan Blindness and Onchocercal Keratitis.*

(1) *Onset.*—In Sudan blindness the initial lachrymation is accompanied by irritation, usually likened to that caused by dust in the eyes or a piece of grass lodged beneath the lids. The lachrymation is of short duration only and passes off, as a rule, in a fortnight or three weeks, when night blindness becomes established.

In keratitis the irritation is severe and pain is often very intense indeed. A common description given by patients is that the pain is burning "as if chillies had been rubbed into the eyes." Some liken the pain to thorns piercing the eye or "hot snakes running about beneath the lids." Occasionally the pain is severe enough to cause the patient to throw himself about and cry out. Lachrymation lasts a long time, sometimes for over a year.

In one case, seen a month after the onset of lachrymation, the pupils were widely dilated, the fundus was covered with patches of pigment, the optic disc was pink and rather indistinct and the conjunctiva was oedematous rather than inflamed. The cornea had lost its lustre to a very slight degree and appeared oedematous. The man could see fingers at 10 feet but could not see anything



at all in the evening. Onchocercal tumours were present on ribs and iliac crests and had been for years.

(2) *Night blindness*.—A constant symptom in Sudan blindness. In keratitis the vision to begin with is better in the early morning and late afternoon, as the glare is then less intense, but later, owing to pupillary adhesions and a small fixed pupil, vision becomes poorer in a bad light.

(3) *Attitude of patient*.—In Sudan blindness the eyes appear normal. One only knows that a man is blind by seeing him being led by his wife and children, but the face possesses that vacant, gazing expression so characteristic of the blind.

In keratitis in its more acute stages the sufferer keeps in the shade, turning the face towards the shadow and shielding the eyes with the hands. Tears stream down his face and his cheeks are encrusted with scales of salt from dried tears.

(4) *Progress*.—The progress of Sudan blindness is rapid, the disease reaching its maximum development in from two to five months and then remaining stationary. The patient is completely blind or has severe impairment of vision or suffers only from night blindness.

In onchocercal keratitis the progress may be rapid. In the early stages defective vision is largely due to acute photophobia. When the acute symptoms have passed off the sight steadily deteriorates as the corneal opacity becomes denser and more extensive. Adhesions slowly obliterate the pupillary aperture and the lens capsule becomes opaque. The process may continue for years, ending sometimes in phthisis bulbi.

(5) *Media*.—In Sudan blindness the media are usually clear, but cataractous changes are not uncommon.

In onchocercal keratitis the media of the eye are usually opaque and, although a fair-sized pupil may be present, examination of the fundus is impossible owing to capsular lens or vitreous opacities and particularly the opacity of the lower half of the cornea.

(6) *Microfilariae* are not found in the anterior chamber in Sudan blindness but are present in keratitis.

(7) Sudan blindness is always bilateral. Onchocercal keratitis is occasionally unilateral.

These differences have been described on general lines, but it will be seen that Sudan blindness and onchocercal keratitis are two separate clinical entities due possibly to a common cause.

#### *Distribution of Onchocercal tumours in relation to Eye Manifestations.*

In some cases the eye conditions described above have preceded the appearance of tumours due to *O. volvulus*. In others, development of ocular lesions and the appearance of tumours have coincided, but sometimes tumours have been present for years before the onset of eye symptoms.

Tumours on the bones of the skull are said to produce a higher proportion

of eye lesions than those elsewhere, owing to the shorter route of access to the eye for migratory embryos.

In America, *O. caecutiens* is said to produce cranial tumours with a high percentage of ocular involvement, whilst *O. volvulus* produces tumours on ribs and iliac crests and elsewhere and causes few eye complications. *O. caecutiens* is said to produce erosion of bone while *O. volvulus* does not. In the Sudan on several occasions deep erosion of the frontal bone has been seen when tumours have been removed.

In the Sudan it would appear that tumours on the head are less common than in the Congo, but still the mastoid process, the temporal bone above and behind the pinna of the ear, the sub-occipital region and the parietal bones are not uncommon sites for tumours, and the writer agrees with HISSETTE that tumours on the head are more apt to give rise to the known ocular manifestations of *O. volvulus*.

Again, the ocular manifestations of American onchocerciasis described by SILVA (1932), JOHNSTONE and LARSEN (1933) correspond in every way with the Congo forms described by HISSETTE (1932). The Sudan disease also seems to be identical with the American. TORELLA mentions that he did not notice the narrow, slit-like pupil said to be characteristic of onchocercal keratitis. HISSETTE describes this, and it is a very common feature of the disease in the Sudan.

It cannot be said that tumours on the head are commoner in patients suffering from Sudan blindness, while in the few eyes examined up to date, none of the pathological appearances said to be typical of the hitherto described ocular manifestations of that parasite have been noted.

It is suggested that the adult worms secrete a toxin which affects the fundus and optic nerve. In favour of a systematic intoxication may be mentioned the bilateral nature of the disease and its rapid course.

Another possibility is that microfilariae of *O. volvulus* congregated in the optic tract produce the perivascular infiltration seen elsewhere (such as in the keratitis). Should this pathological change take place in the chiasma, it would produce bilateral symptoms. If the lesion is in the optic tract, the disease might be called a retrobulbar post-neuritic atrophy. Clinically the appearances of the fundus are those of a diffuse retino-choroiditis.

#### *The vector of O. volvulus.*

The common *Simulium* found is *S. damnosum*. This insect appears in swarms in the evening and disappears directly the sun sinks. It bites anywhere, but seems to prefer the legs. It can be stirred up in the afternoon by beating the long grass along the edge of the stream. The flies are most numerous when the rivers are in flood, and are a terrible scourge whilst fishing. The bite is not felt at the time, but in 24 hours or so a weal appears and itches intensely. The whole body itches in natives exposed to the bites, the face becomes swollen, the eyelids oedematous and the conjunctivae bloodshot.

A similar reaction heralds the onset of a heavy infection with *Onchocerca*, but it is much more severe.

*S. damnosum* was found one kilometre from water in the rest house kitchen at Mvolo in Rumbek district. The flies were present in hundreds. They appeared to be truly domestic, as no flies were noted on the road outside. In native huts one kilometre farther away no Simuliidae were found.

#### SUMMARY AND CONCLUSIONS.

(1) An endemic disease causing blindness in the Bahr-el-Ghazal Province of the Anglo-Egyptian Sudan is described. The disease has become epidemic within the last 5 to 10 years.

(2) The disease is local and found along the banks of rocky streams, geographically its distribution being identical with that of *Onchocerca volvulus*.

(3) Clinically the condition known as Sudan blindness gives the ophthalmoscopic appearance of a diffuse retino-choroiditis with optic atrophy, often with sclerosis of the retinal vessels and the deposition of masses of pigment on the retina.

(4) Pathologically the retina shows an atrophy of the cellular layers, irregular in its distribution, and the passage of pigment forward until it lies in masses on, instead of beneath, the retina. Perivascular reaction, so characteristic of onchocercal keratitis, is not present, and the cornea is not vascularised as in keratitis, but there is considerable vascularisation of the retina. Optic atrophy is almost certainly present.

(5) *Onchocerca volvulus* is recorded for the first time from the Sudan with its various manifestations, including punctate keratitis.

(6) Sudan blindness is believed to be due to *O. volvulus*.

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